THE GEOGRAPHICAL REVIEW

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THE
GEOGRAPHICAL REVIEW

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A POPULATION MAP OF TANGANYIKA TERRITORY

Clement Gillman

[With separate map, Pl. II, facing p. 374.]

IT has long been felt that a map depicting with reasonable precision the distribution of the native population in Tanganyika Territory is not only desirable but essential for the better understanding of many regional problems awaiting solution.[1] A first essay at satisfying this need appears in the map, Plate II, facing page 374, and a first glance at the map confirms the reality of the need. Here is a territory of 342,000 square miles two-thirds of which is uninhabited and on the remaining one-third of which distribution of population is highly localized. No more graphic way could be devised to show that peculiar problems in agricultural development, transportation, labor, and administration confront the government of Tanganyika Territory. An analysis of the map reveals the regional problems in some detail.

The map is concerned with the distribution of the native population only. Although the economic influence of the alien population,[2] both European and Asiatic, is of the greatest importance in many ways, this population is too small and too scattered to be distinguished on our map. The land alienated to nonnatives for agricultural use has, however, been indicated, since a very definite interdependence exists between alienation and native settlements. Forest reserves,

[1] The three native censuses of 1921, 1928, and 1931 give only a rough-and-ready idea of the mean population density of each administrative district, and no government department exists for coördination of the geographical raw material that the administrative and technical departments amass in the course of their routine duties. Under the circumstances the opportunity for compiling the map depended on the coincidence of certain factors: an administration helpful in the collection of data, a compiler with a fair knowledge of the country and the leisure necessary for sifting and plotting the material. This opportunity arrived at long last in 1934, when, at the writer's suggestion, the Chief Secretary to the government issued instructions to the provincial commissioners for the collection of the desired data. The writer is deeply indebted to all officers of the Provincial Administration who have participated in this task for their valuable assistance, without which the fulfillment of his own share would have been impossible.

[2] In 1931 the nonnative population was about 41,000, including 8200 Europeans, 23,400 Indians and 7100 Arabs.

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which play so vital a part in the maintenance of populations, are likewise shown, as well as the more important lines of communication and all boundaries of administrative districts.

Of the three primary factors determining man's occupation of the land, viz. water, soil, and topography, water, itself dependent on climate and rock structure, is of paramount importance in a semiarid, tectonically disturbed region like East Africa. By "water" is meant, of course, a permanent supply of domestic water more or less reliable throughout the year, without which permanent settlement is unthinkable, even where, as in most of Tanganyika Territory, rainfall is enough for the raising of suitably chosen crops. Soil fertility and topography in itself, i.e. apart from its relation to water supply, must be considered of secondary significance.

Another factor intimately related to African population problems is the distribution of the tsetse fly. A distinct interdependence exists between fly density and human-population density, particularly where, as is true of most Bantu tribes, the bulk of the population are cattle-breeding agriculturists. The thicker the fly, the sparser man, and vice versa, is an established truism; but in the writer's opinion there can likewise be no doubt that against an extending or stationary human population dense enough to keep down the harboring vegetation the fly has no chance of surviving. On the other hand, where human pressure relaxes and a suitable secondary vegetation is allowed to capture or recapture the land, the fly immediately follows in its wake. We must divorce ourselves from the view, still widely held, that the fly drives man away. It is man who recedes, generally after having exhausted soil and shallow underground water, and leaves the wasteland to tsetse.

Somewhat more complicated is the case where man, with his methods of shifting cultivation, becomes a pioneer intruder into the vast, dry-savana forest, usually in numbers too small to keep his temporary clearings efficiently open. In this case man is the aggressor and the competitor of an insect apparently much better adapted to a semiarid environment and all its hardships and difficulties in the way of food supply and propagation.

Types of Land Occupation

Classification of the various types of land occupation revealed by the population map must be based on the dominant influencing factor of water supply. This has been done in Table I, which, however, like all other such classifications, only approximately represents the intricate "flux" of nature, with its marginal zones between pure types and its infinite variety of interacting conditions. The accompanying small-scale map shows the distribution of these types and

also the boundaries of the tsetse-free regions slightly adjusted from the latest map of the Tsetse Research Department.[2]

Analysis of the table brings out the following striking facts: The well watered parts of the Territory (I, II, III, and IX) contain two-thirds of the population on one-tenth of the area; the fairly well watered parts (IV and V) contain one-sixth of the population on one-twelfth of the area; and the poorly watered parts, as far as they are inhabited (VI and VII), contain another sixth on one-fifth of the area. Nearly two-thirds of the Territory is entirely uninhabited. Nothing proves better than these figures the close relationship between population density and reliability of water supply and the appalling extent of country lacking enough water to maintain even a sparse population!

That, with few exceptions, all the well watered areas and a large proportion of the fairly well watered areas lie within the tsetse-free belt is evidence for the correctness of the view stated above regarding the relation between the fly and man, especially if one bears in mind that the boundaries merely distinguish between fly-free and fly-infested country without an attempt to illustrate the degree of infestation, which varies greatly from place to place, particularly in the southeast.

High Rainfall Cultivation

Where geologically recent volcanic outpouring or differential uplift has produced relatively higher ground exposed to prevailing moisture-laden winds, condensation, in the form of rain or mist, takes place throughout most of the year and maintains evergreen rain forest in the natural state. Permanent and ample water supplies at short intervals are thus assured and form the basis for close settlement (I). Together with comparative security against invaders, ensured by scarp walls and ravines, these favorable water conditions must have largely overshadowed the somewhat inclement climate and the increased labor of clearing the ground. They have also led to the gradual evolution of a higher cultural standard than that of shifting cultivation as practiced in the surrounding savanas and steppes, including permanent crops such as bananas and coffee, irrigation, stabling of cattle, manuring, and the beginnings of individual land tenure. Population density is very high for East Africa, 87 per cent of the people occupying the districts with more than 150 persons to a square kilometer (Table II) and one-fifth of Tanganyika Territory's

[2] Incidentally, it may be remarked, this treatment of land occupation based on a dominating factor represents what may prove a fruitful departure from the more orthodox methods of regional geography, especially for regions where the factor chosen is itself intimately bound up with other fundamental determinants of landscape, such as structure, climate, and vegetation. The writer is convinced that the checkered pattern of his land-occupation map does greater justice to the actual distribution of the geographical characteristics than all former attempts to divide the country into "geographical regions," within whose boundaries areas of widely different aspects were of necessity included.

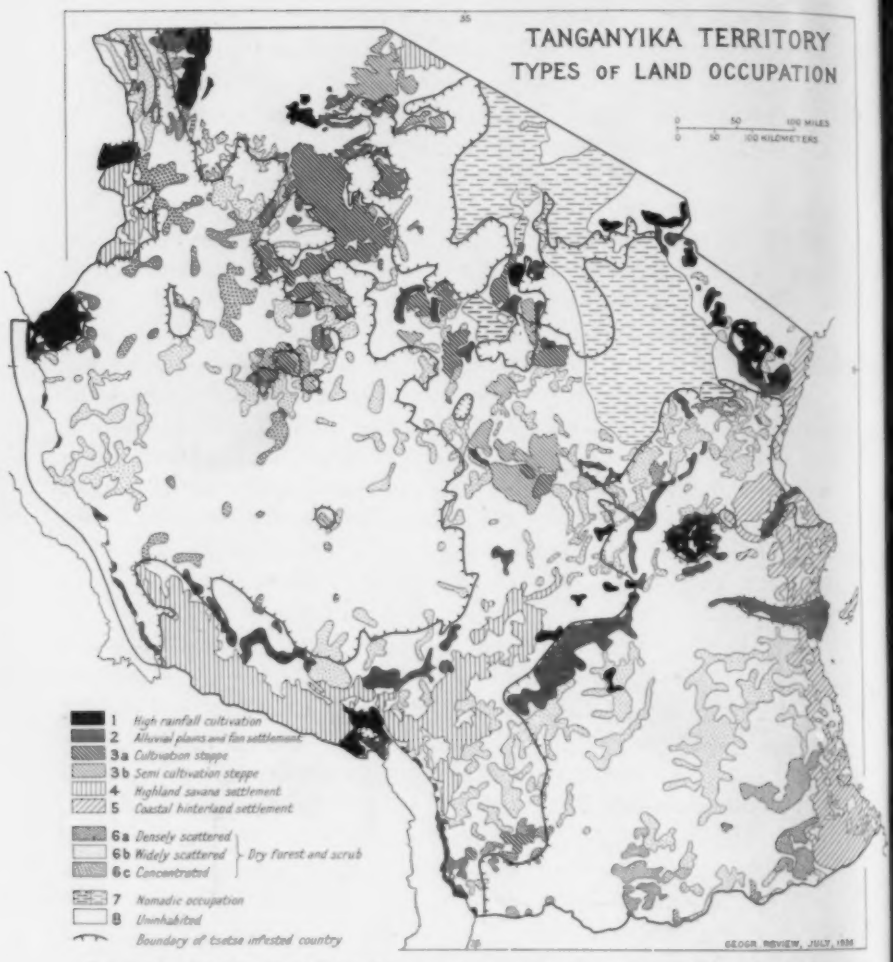


FIG. 1—Map showing distribution of types of land occupation in Tanganyika Territory. Compare with Plate II and Table I. Scale approximately 1 : 11,000,000.

population living on those small areas, which, in addition, have been found attractive by white planters, who occupy a large part of the rain-forest country in the Tanga and Northern Provinces, and which, on the map, stand out like islands from the vastness of the more arid lands.

In their physiographic grouping these "islands" follow closely the main trend lines of the great shatter belts or occupy the gentler slopes of the volcanic masses that rise above the points where tectonic lines intersect.[4] They are largest and most numerous in the northeast, where the easternmost zone of disturbance approaches close to the Indian Ocean; they become smaller and fewer where the great

[4] See E. O. Teale and E. Harvey: A Physiographical Map of Tanganyika Territory, *Geogr. Rev.*, Vol. 23, 1933, pp. 402–413.

TABLE I—TYPES OF LAND OCCUPATION

REF. NO.	TYPE	NATURE OF WATER SUPPLY	AREA		POPULATION		MEAN DENSITY PER SQ. KM.
			Square Kilometers	*% of Territory*	*Numbers (to nearest 5000)*	*% of Total*	
I.	High Rainfall Cultivation (generally based on banana).	Permanent streams or springs. Rainless months very few.	15,000	1.7	995,000	21	66
II.	Alluvial Plain and Scarp-Foot Fan Settlement.	Permanent streams or springs, but occupation handicapped by annual floods or distance between water supplies.	29,000	3.3	500,000	10	17
IIIa.	Cultivation Steppe.	Ground water easily accessible at short intervals.	26,000	2.9	1,220,000	25.5	47
b.	Semi-Cultivation Steppe.	Either as in IIIa, but of comparatively recent origin or advanced exhaustion; or accessible ground water at longer intervals.	16,000	1.8	310,000	6.5	19
	Total		86,000	9.7	3,025,000	63	35
IV.	Highland-Savana Settlement.	Permanent streamlets (many of them "strangers" from adjoining areas) and springs at fairly wide intervals.	41,000	4.6	370,000	7.5	9
V.	Coastal-Hinterland Settlement (on Mesozoic and Tertiary sediments).	Geologically and morphologically determined springs, shallow ground water, permanent swamps, and stranger rivers.	28,000	3.1	500,000	10	18
	Total		69,000	7.7	870,000	17.5	13
VI.	Dry-Savana and Thorn Settlement.	Sporadic ground-water supplies.					
a.	Densely scattered.		14,000	1.6	205,000	4	15
b.	Widely scattered.		83,000	9.4	435,000	9	5
c.	Most antifly concentrations.		14,000	1.6	180,000	4	13
	Total		111,000	12.6	820,000	17	7
VII.	Seminomadic and Nomadic Pastoralists.	Very sporadic.	68,000	7.7	40,000	1	0.6
VIII.	Uninhabited.	Mostly absent.	553,000	62.3	. . . . .	. . . .	. . . . .
IX.	Townships.	Generally artificial supplies.	. . . . .	. . . .	70,000	1.5	. . . . .
	TOTAL		887,000	100.0%	4,825,000	100.0%	5.5

eastern scarp recedes southwestward from the sea; they almost disappear in the central shatter belt, whose high blocks generally lie

in the rain shadow of those of the eastern belt; and they increase again in number and extent west of Lake Victoria, whose vast evaporating surface provides the prevailing easterly winds with fresh moisture. Similarly, in the far southwest, Lake Nyasa is the cause of the small Rungwe area of condensation.

Although a close relationship is revealed between tectonically determined exposure to a trade-wind climate and population density,

TABLE II—AREAS WITH POPULATION DENSITY EXCEEDING 150 PER SQ. KM.*

UNIT	DISTRICT	AREA (*Sq. Km.*)	NUMBER OF PEOPLE	MEAN DENSITY PER SQ. KM
Kiatwara	Bukoba	150	23,000	153
Rubafu	Bukoba	24	4,700	191
Kanyigo	Bukoba	30	8,800	290
Buyango	Bukoba	20	8,500	425
Kitobo	Bukoba	16	7,600	475
Ibuga	Bukoba	50	17,700	354
Part of Mwanza	Mwanza	120	19,200	160
N. Usukuma	Mwanza	55	9,600	174
S.E. Ukerewe Island	Mwanza	120	24,100	201
Ukara Island	Mwanza	50	17,000	340
Mwaia	Rungwe	28	11,000	393
Central & W. Meru	Arusha	165	37,200	225
S. & E. Kilimanjaro	Moshi	550	150,000	273
S.-Central Uluguru	Morogoro	140	21,800	156
Mikindani and outskirts	Mikindani	32	7,800	243
Total		1550	368,000	237

*By combining these figures with those in Table III it will be seen that 7.6 per cent of the population live on these patches, which represent only 0.17 per cent of the Territory s total area.

soil fertility shows no such relationship. The areas of high rainfall cultivation are fairly evenly distributed over the rich soils of recent volcanoes, the deep loams of the old schist complex, and the poorer arenaceous soils produced by the granites and the Paleozoic sediments around Lake Victoria. Indeed, of the three most densely occupied areas in the Territory, with more than 400 people to a square kilometer (1000 to a square mile), two are found on the arenaceous soils in the Bukoba District and only one on Kilimanjaro (Kibosho County). There may be a connecting link, however, in the fact that all these soils, whatever their parent rock, have been equally enriched, during the period of reaching maturity, by the climatically determined forest cover.

Topography seems to play a more important role; for the steeper slopes of typical rain-forest country are as yet hardly touched by man, particularly those intensely dissected parts of the high blocks that adjoin the mighty scarps, as in western Usambara and in Udzungwa. On the other hand, as Uluguru and parts of Kilimanjaro and Meru show, pressure of population, largely engendered by the blessings of *pax Europaea* and its consequences,[5] drives the people in ever increas-

[5] C. Gillman: Some Geographical Controls in East Africa. *South African Geogr. Journ.*, Vol. 15, 1932, pp. 3–14.

ing numbers on almost impossible slopes—with sad results for forest conservation and water supply.

Alluvial Plains and Scarp-Foot Fans

This type (II) comprises two very distinct forms of human occupation, which nevertheless resemble each other in their striplike arrangement, in their dependence on permanent streams and springs, and in certain obstacles preventing that close and practically continuous settlement that characterizes the high rainfall cultivation.

In a country owing its present surface forms to geologically recent crustal movements of considerable dimensions, which thoroughly disturbed preëxisting drainage lines, it is not surprising that true alluvial plains are, if not conspicuous by their absence, yet a minor feature of the landscape. On the other hand, scarp-foot fans are common in the East African shatter belts. In many places they are composed of good soil derived from the decomposition of the ancient complex, now exposed to weathering by recent uplift, and they are comparatively well watered. A combination of the two types is found where, in the less arid regions, the tectonic troughs are partly filled by Lakes Tanganyika and Nyasa, along the shores of which scarp foot coincides with lake level and small alluvial plains fill the embouchures of the valleys descending from the high blocks.

Unfortunately for the expansion of human settlement, these types are burdened with serious handicaps. The few real alluvial plains, such as those of the Rukwa, upper Ruaha, Kilombero, lower Rufiji, and Ruvu, comprise large areas subject to annual inundation and thus unfit for permanent human occupation. The scale of the occupation map fails to bring out this fact, but reference to the dot map will show to what extent these plains are, for all practical purposes, uninhabited. Similarly the fan lands—narrow strips along the foot of scarps—are shown as continuous, though in reality human settlement is tied to the fans of individual scarp streams or to scarp-foot springs, separated by intervening stretches of waterless, and therefore unoccupied, ground. In the northeast quadrant of the Territory, notably around the Usambara and Uluguru Mountains, along the Great Scarp, and on the lower Rufiji, the available land is shared by the natives with alien settlers and planters, both European and Indian. The lake shores, although amply provided with unlimited water from the lakes, show scarp slopes too steep for effective occupation. Except in the rare cases in which the mouth of a scarp valley has been sufficiently leveled by sediment, the population is confined to very narrow and much interrupted margins. This type of land occupation seems to be independent of parent rock and soil and extends through a variety of climatic types.

FIG. 2—Lower slopes of Mount Meru near Arusha township depicting occupation type I. The fields and banana groves on the right and lower part of the picture contrast with the European coffee estate (note the shade trees) in the upper left-hand corner. The round "beehive" huts of the natives are hidden to the pedestrian among the bananas but revealed to the traveler by air.

CULTIVATION STEPPE

Under the present distribution of population the "Cultivation Steppe"[6] (III) not only feeds one-third of Tanganyika Territory's inhabitants but allows Bantu man to keep those large herds of cattle and flocks of goats (in 1933 about 2.8 million cattle and 3 million sheep and goats), that to him still are, unfortunately, the only "wealth" wherewith to buy his women. There can be no doubt that these granaries and sources of man power constitute today the most important factor in the country's internal economics and directly and indirectly, as providers of plantation labor and buyers of imports, contribute largely to its external trade.

The areas of cultivation steppe, large and small alike, are without

[6] The term "cultivation steppe" (the *Kultursteppe* of the German authors) is so well established in East African geographical literature that the writer has retained it, though the type is found replacing both typical dry-savana forest and typical thornbush steppe.

FIG. 3—Alluvial plain settlement on the lower Rufiji. Note the paddy fields in the lower center and the large areas occupied by unreclaimed swamps, along former river arms, or by bush.

exception veritable oases within either very sparsely inhabited or entirely uninhabited land. Nearly everywhere the change from high population density to zero is a sudden jump rather than a gradient. Why this astonishing and sudden change under a uniform climate with its sufficient though unreliable seasonal rainfall of 600 to 900 millimeters? The answer is simple. Presence or absence of a permanent domestic water supply in the form of comparatively shallow ground water within reach of primitive tools and skill dictates the pattern of population.

The shallow ground water itself is intimately linked with geological structure and morphological state. It is found only where the younger granites or, in rare instances, the granitic gneisses of the old complex, as at Kondoa Irangi, now form a residual relief characterized by inselberge or ridges. These granite tors and ridges, with their fantastic "woolsack" formations and their outcrops of highly jointed rock, are admirably suited to the conservation of a high percentage of the seasonal rainfall, especially where their natural cover of dense scrub

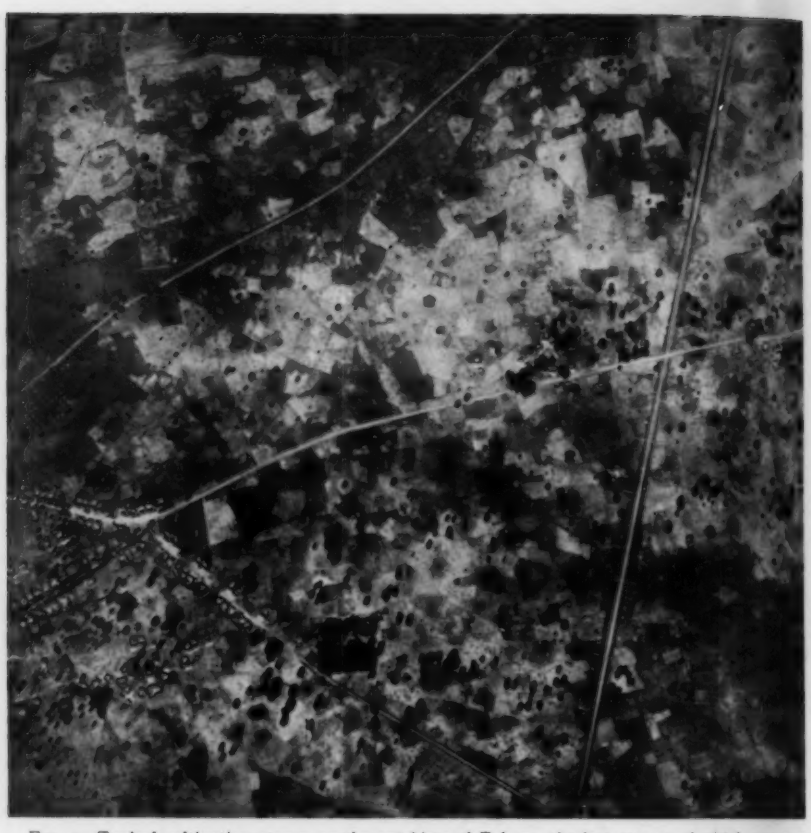


FIG. 4—Typical cultivation steppe on the outskirts of Tabora, the last streets of which are seen near the left bottom corner. The black spots are mango trees, a permanent crop introduced by the Arab slave traders. Note the Central Railway.

is still preserved from the ravages of goats. This stored water is given out in the form of seepage springs or as a more or less permanent flow of underground water in the sandy beds of the intermittent streams descending along the wide *mbuga* valleys.[7] Storage capacity is greatly increased by the extent of porous, limonitic crusts or pans that fringe many of the hills. Where the country rock changes from granite to the old schists or where for tectonic reasons the modeling of a typical inselberg landscape has not yet begun, the water supplies, and with them dense population, cease rather suddenly.

The soils of these areas—including granitic sandy loams of the foot slopes, colluvial types resulting from redistribution by sheet-

[7] An "mbuga" or "buga" (the "vley" of South Africa) is a badly drained depression, covered by clayey alluvium and subject to annual inundations lasting long enough to prevent the growth of any trees except that of the specially adapted White Gall Acacias (*Ac. Seyal* var. fistula, *Ac. Fromicarum*, etc.). Its vegetation is, thus, predominantly grassland. Where, through tectonic causes or through the activities of man, back-cutting takes place stream beds, usually with a sandy bottom, establish themselves (compare C. Gillman: "Accelerated Erosion as a Consequence of Human Activity," *Zeitschr. für Geomorphologie*, Vol. 7, 1932–1933, pp. 291–295).

FIG. 5—Cultivation steppe covering the granite hills adjoining Lake Victoria just south of Mwanza Town. Note the granite tors near the upper margin.

floods, and alluvial black clays on the lowest gradients—derived from identical parent rocks and formed under similar climatic conditions, show great areal uniformity. It must not be inferred, however, that their fertility is greater than that of the soils in the adjoining uninhabited strips of country. On the contrary, whereas the soils of these uninhabited areas are still more or less virgin or, where formerly under the shifting cultivation of scattered dry-forest settlement, are regenerated, those of the cultivation steppe are being allowed to deteriorate to an appalling degree.

On the occupation map two types of cultivation steppe are distinguished: a fully developed one (IIIa) and what is termed "Semi-Cultivation Steppe" (IIIb). In the former, vestiges of the original vegetation, if found, are few. In the latter, the original vegetation occupies larger areas. The cause may be the longer intervals between ground-water supplies, as in central Ugogo; or recent outspreading from congested areas into marginal ground, as is illustrated by the rapidly extending fringe around the Tabora oasis or by the long lobe

that is being pushed northward from the doomed oasis of Kondoa Irangi; or the gradual exhaustion of soil and water supply, followed by shrinking population and advance of bush and, eventually, of fly, as—probably—in western Usandaui.

The fundamental condition for the formation of cultivation steppe,

FIG. 6—Scarp foot settlement on the western foot of the Kiboriani high block in Mpwapwa District. The road shown is the main road from Mpwapwa to Dodoma. The bush is arid deciduous thorn.

namely the existence of granites at a particular stage in the cycle of denudation, limits sharply this type of human occupation, even on the vast central plateau, where suitable granites no doubt are present; but back cutting from the relatively lower crust blocks or troughs has not as yet succeeded in dissecting the early-Tertiary (?) peneplain. Only a comparatively small part of Tanganyika Territory is structurally suited to the development of cultivation steppes, and it would be a mistake to think that, after exhaustion of the soil and water, the one and a half million people who live on and from these steppes today can simply shift into the surrounding "wide open spaces." The "spaces" are there, but the life-sustaining water is not!

These three comparatively well watered types of human occupation admit of a clear-cut definition based on easily discernible physiographic and hydrographic features. The next two types (IV and V) are less well defined and will, no doubt, require subdivision on closer study. For the present purpose they form a useful preliminary attempt to distinguish between regions that show, on the whole, similar patterns of distribution under differing climatic, geological, and physiographic conditions.

Highland-Savana Settlement

This type (IV) covers the southwestern highlands in a practically continuous arc and reappears in the far northwest as the easternmost outlier of a similar form that extends across Urundi and Ruanda in the territory of the Belgian mandate. Its climate is that of the

Fig. 7—The last stages of an exhausted and already nearly deserted cultivation steppe. Kondoa Irangi District.

subarid-subhumid transition zone. The rainfall of the southwestern highlands, which ranges from 900 to 1400 millimeters and is distinctly unreliable, is less than might be expected from the altitude. This is accounted for by distance from the coast and the fact that much of the area is screened by higher scarp edges from both the sea and Lake Nyasa, together with strong dry-weather winds and high evaporation. The natural vegetation consists largely of the more luxuriant formations of mountain savana in the lower parts; of open grassland or mountain scrub, probably the man-created successors of a former, more extensive rain forest, in the higher parts.

On the other hand, the scarp edges and occasional islands of higher ground where condensation is more regular send out permanent streams and streamlets that traverse the surrounding land as "strangers" and form the foundations of human settlement. Occasional spring horizons also form loci of settlement, especially in the regions where recent tectonic uplift has exposed the ancient unconformity between the old crystalline rocks and Paleozoic sediments. The mottled geological pattern and accentuated relief cause topog-

FIG. 8—An isolated patch of highland occupation along the Great North Road in the Mbeya District. Note the fairly successful result of inducing the natives to till along contours.

raphy, local climate, and soil to vary widely. To this must be added historical events, such as the great waves of Zulu invasion and the rebellions during the early stages of European rule, for a realization of the many intricacies of population distribution to which the small scale of the map and the lack of detailed investigations do not do justice. This applies particularly to Ufipa, one of the few districts of which the writer has no personal knowledge.

In this region native occupation is distinctly patchy, mean density is comparatively low, and local variations in density are pronounced. Topographically determined areas of uninhabited land, although perhaps smaller than in the more arid parts, are more numerous than the map may suggest. European settlement has recently invaded the more promising of these areas.

COASTAL-HINTERLAND SETTLEMENT

The fundamental factor that allows the comparatively narrow strip of coastal hinterland to be regarded as a unit (V) is its uniform geological structure. Throughout its extent, from the Kenya border in the north to the Rovuma River in the south, it is built up of Meso-

FIG. 9—Densely occupied ground in the coastal belt on the borders of Dar-es-Salaam. Note the rectangular native huts and the rows of coconut palms. The black vegetation along the creek is mangrove.

zoic and Tertiary sediments, generally, but not universally, of marine origin, which for long ages have been deposited, removed, and redeposited on an unstable shelf forming a "hinge" between the rising crystalline continent on the west and the great Indian basin on the east. Repeated up-and-down movements of the crust have modeled the limestones, sandstones, shales, clays, and marls into surface forms that, although differing greatly from place to place, yet show regionally their common structure and history.

The climate is somewhat more humid than that of the adjacent interior, and some of the coastal-plateau blocks even rise high enough for condensation to take place to a certain extent, though nowhere enough to maintain proper rain forest. Exposure to the trade winds varies with the checkered surface, and moister and drier belts alternate in many places. The soils, too, are of great diversity and varying permeability. Reliable water supplies are by no means evenly distributed. Along the southern plateaus, where the unconformity between the crystalline schists and the Mesozoic sediments is exposed in many places, it forms excellent spring horizons. Elsewhere shallow ground water, which, in places, reaches the surface in permanent

swamps, can be relied on; a few permanent rivers traverse the belt on their way to the coast. The map reveals clearly by its "jigsaw puzzle" pattern of intertwining inhabited and uninhabited patches how much man depends on the hazard of morphologically and geologically determined sources of water. An interesting case of the great distance from a source at which man will make his home is furnished by the comparatively densely settled Makonde Plateau south of Lindi, whose inhabitants regularly walk several hours to springs, 250 meters farther down at the foot of the escarpments.

This coastal strip also includes a fair number of people who live largely by fishing and obtain their domestic water from rather brackish water holes. Much of the area is occupied by sisal estates owned by nonnatives, part of whose labor force live permanently as squatters on the land.[8]

Dry-Savana and Thorn Settlement

A clearly defined type of settlement is that of the dry-savana and thorn country (VI). It covers vast expanses where permanent water is found only sporadically and where permanent occupation of the land, if possible at all, is of necessity scattered. Climatically the area covered by this type ranges from the distinctly subarid conditions of the deciduous-scrub steppe, generally tsetse-free, to the more humid ones of the dry savana forest (*myombo*), where the tsetse fly reigns supreme. Settlement seems to take little heed of soil nature. It is found on residual or colluvial soils derived from all kinds of parent rock and avoids only the heavy alluvial clays of the seasonally inundated *mbugas* characteristic of the gently rolling peneplain landscape of the plateaus.

The sporadic water supplies themselves, dependent as a rule on some topographical or geological feature, are not necessarily poor, though, on the other hand, the deep, tortuous, and inclined wells of southern Ugogo show that even the most precarious sources are being utilized. The long distances between supplies, rather than their volume or reliability, determine the dry-savana type of settlement. Long miles of unproductive wastes separate "neighboring" clearings or clusters of clearings, and even the speed of air travel cannot overcome the observer's impression of a practically empty wilderness.

In a few areas of limited extent (VIa), more favorably endowed with sporadic water, the scattering may become a little less pronounced. But the bulk of the 111,000 square kilometers (or one-eighth of the Territory) taken up by this form of human occupation shows only "widely scattered" settlement (VIb). The extent of the area

[8] The fluctuating seasonal labor here and elsewhere on plantations and in the gold fields being newly developed has not been incorporated in the dot map. Such labor forms only an insignificant part of the population.

occupied by this subtype has lately been reduced by the gathering of a population of 180,000 into a few concentrations as a measure against sleeping sickness (VIc). In many places this concentration is based on water supplies artificially increased by the administration. The dot map shows the difference in settlement pattern instructively along the boundary between western Mwanza and Kahama Districts. North of the boundary, where concentration has not as yet taken place, the original pattern is seen; south of it, where concentration is complete, the newly created artificial pattern stands out clearly. It is evident that these concentrations have considerably increased the total area of "uninhabited" land (VIII).

Nomadic Occupation

Where permanent water supplies are even more sporadic and precarious and consist, moreover, in most places of more or less brackish water, settlement based on agriculture ceases, and the rule becomes nomadic occupation by pastoralists, who as far as possible "follow the rains" (VII).

On the margins of these lands, which cover about 8 per cent of the Territory, may still be found small areas where the nomads gather more thickly and may occasionally till the soil. Even so, man must rely for his liquid food to a large extent on the chemical laboratory of his cattle's digestive organs, in which the saline water, which the cattle are just able to drink, is converted into "sweet" milk. This, for example, is the case in the Watatoga country of southern Mbulu. In other parts, as around Mt. Meru, whose surplus waters discharge on the surrounding plains, several furrows and, in at least one place, a modern pipe line have led to what might be termed "nomadism under irrigation."

Rainfall statistics are scant for the Masai Reserve, which practically coincides with the main area of nomadic occupation; but scrutiny of the latest rainfall maps[9] reveals that this region receives not less but probably substantially more rain than the areas of cultivation steppe adjoining it on the west. However, the inselberge of the Masai Steppe are not of granite and are, moreover, widely spaced, so that one of the prerequisites for the formation of cultivation steppes is lacking. On the other hand, the more this uninviting country is studied, the more evidence is collected of a former occupation by agriculturists—dried-up wells, some of considerable depth; cultivation ridges not as yet wholly obliterated; vegetation forms of the same type as are found elsewhere on formerly tilled and now deserted land. Thus arises the question whose clearer elucidation is urgently re-

[9] Especially W. Paap: Die Niederschlagsverhältnisse des Schutzgebietes Deutsch-Ostafrika, *Archiv der Deutschen Seewarte*, Vol. 53, 1934.

quired: Do we not possess in these areas examples of the end product of man-created soil deterioration and desiccation? And if a former, sedentary population has been forced by increasing impoverishment through soil erosion and a corresponding lowering of the ground-water table to evacuate their home lands, leaving them to the less exacting nomad, is not this population repeating the process of destruction elsewhere at the present moment?

Uninhabited Regions

More than 62 per cent, or 553,000 square kilometers (214,000 square miles), of Tanganyika Territory—largely in the form of continuous blocks, especially in the center and the west—is uninhabited (VIII).

Analysis of this regrettable though geographically inevitable state of affairs distinguishes two main causes. The greater part of the wasteland is undoubtedly ascribable to the lack of permanent domestic water, aggravated by the fact that wide tracts, waterless during the dry season, are subject to annual inundations during the rains. A rough estimate shows that 80 to 90 per cent of the uninhabited regions belong to this category.

The remaining 10 to 20 per cent comprise the following: forest reserves; lands alienated to nonnatives but not as yet under cultivation; permanent swamps, such as those along the middle Malagarasi and its tributaries in the lowest part of the Unyamwezi Basin; the upper reaches of the great volcanoes, climatically unfavorable; and the steep and tortuously dissected scarps of the shatter belts.

Townships

Only 70,000 natives, or 1½ per cent of the total population, live in the 12 urban agglomerations that alone deserve the name "township." They are:

1. Dar es Salaam	23,000	4. Tanga	5,000	7. Moshi	3,900	10. Dodoma	3,000
2. Tabora	8,000	5. Morogoro	4,700	8. Lindi	3,700	11. Pangani	2,500
3. Ujiji	6,200	6. Mwanza	4,400	9. Bagamoyo	3,600	12. Kilwa	2,000

Most of this locally intensified density, due largely to European administration, commerce, and industry, has been made possible only through water supplies artificially increased and assured by European capital and technical skill. All the towns enumerated, except a few of the smaller ones (Kilwa, Pangani, and Bagamoyo), which still depend on more or less primitive wells, have today modern piped supplies derived either from the lower ground water by deep wells and boreholes (Dar es Salaam, Tanga, Tabora, Dodoma); from lakes, springs, or streams (Morogoro, Lindi, Mwanza, Ujiji, Moshi); or, experimentally, from impounded floodwater (Dodoma).

TABLE III—DISTRICT TOTALS

PROVINCE	DISTRICT	AREA (Sq. Km.)	TOTAL POPULATION (INCLUDING TOWNSHIPS)		MEAN DENSITY PER SQ. KM	NUMBER OF UNITS USED FOR MAP	SOURCE OF COUNT
			1934 Figures Used for Map	*1931 Census*			
LAKE	Kwimba	4,710	191,700	200,000	40.7	266	Total 1934
	Shinyanga	9,470	146,500	144,500	15.5	91	Total 1934
	Maswa	23,200	194,400	230,000	8.4	326	Total 1934
	Mwanza	14,470	287,900	254,500	19.9	202	Total 1934
	Musoma	20,730	195,900	184,000	9.5	43	Total 1934
	Biharamulo	11,470	90,700	100,200	7.9	19	Total 1934
	Bukoba	15,760	287,600	277,200	18.3	51	Total 1934
	Total	99,810	1,394,700	1,390,400	14	998	
WESTERN	Kahama	17,390	76,000	76,200	4.4	111	Tax Register
	Nzega	14,420	116,900	116,100	8.1	8	Total 1934
	Tabora	85,620	154,300	211,400	1.8	200	Tax Register
	Uha	23,580	181,500	184,600	7.7	36	Tax Register
	Kigoma	29,210	36,800	30,900	1.3	47	Tax Register
	Ufipa	33,000	92,800	78,500	2.8	48	Tax Register
	Total	203,220	658,300	697,700	3.2	450	
NORTHERN	Arusha	3,000	45,200	49,100	15.1	38	1931 Census
	Moshi	6,100	163,700	164,100	26.8	25	Totals 1934
	Mbulu	16,650	96,500	98,800	5.8	30	Totals 1934
	Masai	61,500	34,500	32,200	0.6	16	Totals 1934
	Total	87,250	339,900	344,200	3.9	109	
CENTRAL	Mkalama	8,670	113,000	117,700	13.0	6	1931 Census?
	Singida	12,300	125,000	132,500	10.2	4	Tax Register
	Manyoni	25,510	41,400	43,600	1.6	11	Totals 1934
	Kondoa Irangi	16,410	98,300	118,200	6.0	13	Tax Register
	Dodoma	17,150	130,000	130,300	7.5	15	Totals 1934
	Mpwapwa	11,130	40,500	37,400	3.6	14	Totals 1934
	Total	91,170	548,200	579,700	6	63	
IRINGA	Mbeya	59,200	106,400	84,600	1.8	46	Tax Register
	Rungwe	4,590	147,100	195,000	32.0	11	Totals 1934
	Njombe	20,300	125,500	125,500	6.2	9	Totals 1934
	Iringa	37,800	67,000	86,800	1.8	72	Tax Register
	Total	121,890	446,000	491,900	3.7	138	
TANGA	Pare	8,100	56,400	57,900	7.0	9	Totals 1934
	Usambara	8,600	110,700	111,800	12.9	17	Totals 1934
	Handeni	12,350	66,200	63,900	5.4	129	Tax Register
	Tanga	3,490	94,700	104,500	27.0	102	Tax Register Admitted inaccurate
	Pangani	2,050	19,800	17,900	9.7	39	Tax Register
	Total	34,590	347,800	356,000	10.1	296	
EASTERN	Bagamoyo	9,330	51,200	62,000	5.5	32	Totals 1934
	Dar es Salaam	9,820	131,300	152,900	13.4	137	Tax Register
	Morogoro	19,100	137,900	155,100	7.2	97	Tax Register
	Kilosa	14,180	60,700	68,700	4.3	92	Tax Register
	Rufiji	19,900	90,500	87,400	4.5	203	Tax Register
	Mahenge	34,780	79,300	93,200	2.3	24	Tax Register
	Total	107,110	550,900	619,300	5.1	585	
SOUTHERN	Kilwa	48,300	82,000	81,400	1.7	73	Totals 1934
	Lindi	11,750	118,200	128,400	10.0	22	Tax Register
	Mikindani	3,600	46,800	46,800	13.1	65	1931 Census
	Newala	3,800	77,500	75,500	20.4	12	Totals 1934
	Masasi	13,300	53,100	49,100	4.0	20	Tax Register
	Tunduru	18,800	47,300	46,500	2.5	34	Tax Register
	Songea	41,930	113,800	115,800	2.7	112	Totals 1934
	Total	141,480	538,700	543,500	3.8	338	
WHOLE TERRITORY		886,520	4,824,500	5,022,700	5.5	2977	

Relationship between Communications and Population

There can be little doubt that the Territory's two trunk railroad lines are, on the whole, correctly aligned. The northern line joins the densely populated volcanoes with the port of Tanga and serves en route the high blocks of Pare and Usambara and their scarp-foot settlements.[10] Apart from the fact that technically it is the line of least resistance, the central railroad, from Dar es Salaam to Lake Tanganyika, connects more areas of closer settlement than any other feasible route between coast and lake. It has the additional advantage of running comparatively close to the great cultivation steppes of the northwest quadrant. That any railroad in Tanganyika Territory will include long stretches through uninhabited and unproductive regions is inevitable and is, incidentally, one of the reasons why its railroads will probably always remain a financial burden to the country.

It is, on the other hand, an interesting point for conjecture whether the two branch lines, from Tabora to Mwanza and from Manyoni into the cultivation steppes of Singida and Mkalama, would have been built had the detailed picture of the present population map been available at that time; for a glance at the map makes it clear that a single branch extending the present Singida line across the Manyonga plain west of Lake Eyasi and joining with the north half of the Mwanza line a little east of Shinyanga not only would have served equally well practically the same number of people but would have shortened the haul from Mwanza to the coast by 100 kilometers.

With regard to the regions not yet provided with rail transport, particularly the southwest quadrant and the hinterland of Lindi, the map confirms the correctness of a policy that can no longer find a justification for costly railroads to assist the meager agricultural potentialities. For so scattered a population the Diesel-engined road train affords a cheaper and more efficient solution of transport problems.

Outlook into the Future

After this short discussion of the more prominent features of the population and occupation maps it is perhaps permissible to indicate at least some of the ways in which the maps can help future development by a "planning" based on geographical facts rather than on uninformed hopes and aspirations.

First and foremost is the concentration of two-thirds of the country's population on the one-tenth of its area that alone possesses enough natural water to maintain such concentration. That many of these "oases," especially those where man shares the soil with his

[10] An alignment along the eastern foot of southern Pare instead of the western would probably have been a better solution.

beloved cattle and goats, have reached or are dangerously near congestion is well known. So also is the deplorable exhaustion of both soil and water consequential to congestion. In the second place, the vast uninhabited and sparsely inhabited regions, which, with 82.6 per cent of the surface and 18 per cent of the population, have an average density of only 1.4 people to a square kilometer (3.6 to a square mile), can by no stretch of the imagination be looked on as "reserves" destined to accommodate the dense masses if and when they have wasted and been driven from their heritage. To counteract such a disaster, only two ways seem to exist. All available financial and administrative means might be devoted to mitigating and eventually stopping the deterioration of the mountain and cultivation-steppe oases. This would involve the enforcement of more enlightened soil and animal husbandry than that of the Bantu population at present. Or provision should be made for the water without which the present wastelands cannot be occupied. The practical solution will probably consist of a combination of the alternatives: saving what still can be saved in the oases and opening up sufficient land in the waterless areas by tapping the lower ground water or storing the runoff of the rainy season with the help of modern technical methods.

It is the writer's conviction that the provision of domestic water supplies by the indicated methods in areas where cultivation under rainfall is possible will prove more economical than irrigation schemes in districts with insufficient or not sufficiently reliable rainfall. The scarcity of true alluvial lands and the high evaporation must not be forgotten. Most of the soils topographically and hydrographically suitable for irrigation are residual and are liable to become saline unless costly drainage is resorted to. Even the methods advocated as more economical cannot be considered as fully satisfactory because the topography does not lend itself readily to efficient storage under high evaporation, and the pumping of the lower ground water may well become a "mining" of by no means inexhaustible resources. All of which goes to prove the urgent necessity of a hydrographic survey to supplement the results of this population survey and to illustrate once more the difficulties, the precariousness, of life in the much overrated tropics.

APPENDIX: METHOD AND CONSTRUCTION OF THE MAP

A great deal of thought was given to the choice of method, and it was a fortunate coincidence that, just before the work of plotting was begun, Professor C. B. Fawcett's lucid paper on "Population Maps" and the illuminating discussions following it[11] were published. A careful study of this paper confirmed the writer in his conclusion that for the purposes of the Tanganyika map and with the material available the dot method was undoubtedly the one to be employed. Except for experimental

[11] "Population Maps: A Discussion . . . . Opened by Professor C. B. Fawcett," *Geogr. Journ.*, Vol. 85, 1935, pp. 142–159.

variations and combinations,[12] population maps can be classed as dot maps, discontinuous-tint maps, and isopleth maps.

The isopleth method, although representing new and interesting attempts to grapple with an admittedly difficult technique, is open to several criticisms. It certainly does not lend itself to depicting very steep density gradients. The sudden changes from high density to zero so characteristic of large parts of semiarid East Africa cannot be brought out by an isopleth map "with its uninterrupted gradational density sequences."[13]

The discontinuous-tint method offers the advantage of presenting direct visible information of absolute density and is acceptable if data are available for units small enough to permit correct representation. But such data, both of census and of topography, are as yet unobtainable for Tanganyika Territory. The dot method, with its clusters, "streamlines," and other patterns, brings out more vividly and tangibly the interdependence between morphology and settlement than even the most detailed density tints can hope to do.[14] A relatively accurate picture of the arrangement or "pattern" of population is of particular value to a country in a primitive stage of development, where the factor of primary interest is that the people live on and from a particular area and not on and from another! Scale likewise enters into these deliberations; for any unit small enough to be reasonably looked on as possessing an even density would in most of the more densely populated parts of East Africa be too small to be plotted on a 1 : 1,000,000 map, not to mention smaller scales. The dot map itself shows the futility, except for a preliminary geographical analysis, of preparing for East African countries a tint density map based on the district or even the subdistrict as the smallest unit. Dixey,[15] who has produced such a map for Nyasaland, is fully aware of its shortcomings; and the writer's remarks on his own first attempt[16] to grapple with the population problems in southwestern Tanganyika Territory by the same method point in the same direction.

For the basic data of population distribution the administrative officers in charge of districts were asked to provide "details of population taken from the most recent census or from the tax assessment rolls, whichever is considered to give more accurate data. In the latter case it will be necessary to multiply the number of tax-payers with the coefficient customary in the district and which usually varies between 3 and 3.5. The units dealt with should be the smallest available, especially in the more sparsely populated areas." A suitable register form sent out for this purpose was returned together with district maps on which the positions of the head villages of the units had been marked as accurately as possible and also, where feasible, the approximate boundaries of the units. As a rule, the maps used were the sheets of the old 1 : 300,000 map of German East Africa.[17] Only a few more recent and improved maps were available. The register also contained a column for "General Remarks" regarding the type of distribution.

Boundaries and head villages of the units were then plotted by the writer on

[12] See, for example, Sten De Geer: A Map of the Distribution of Population in Sweden, *Geogr. Rev.*, Vol. 12, 1922, pp. 72–83 (also Vol. 16, 1926, pp. 341–343); Max Friederichsen: Die Dasymetrische (dichtemessende) Karte des Europäischen Russlands, *Petermanns Mitt.*, Vol. 70, 1924, pp. 214–215; C. J. Bollinger: A Population Map of Central Oklahoma for 1920, *Geogr. Rev.*, Vol. 20, 1930, pp. 283–287.

[13] W. L. G. Joerg: Geography and National Land Planning, *Geogr. Rev.*, Vol. 25, 1935, pp. 177–208; reference on p. 202.

[14] An excellent example of this advantage of dots is afforded in C. E. Batschelet: A Picture of the Distribution of Population in Pennsylvania, *Geogr. Rev.*, Vol. 17, 1927, pp. 429–433.

[15] F. Dixey: The Distribution of Population in Nyasaland, *Geogr. Rev.*, Vol. 18, 1928, pp. 274–290.

[16] C. Gillman: South-West Tanganyika Territory, *Geogr. Journ.*, Vol. 69, 1927, pp. 97–131; reference on p. 120.

[17] Richard Kiepert, Paul Sprigade, and Max Moisel: Karte von Deutsch-Ostafrika, 1 : 300,000, Dietrich Reimer, Berlin, as reproduced by the Geographical Section, General Staff, War Office, London, *G.S.G.S. 3026*, 1915–1916.

The American Geographical Society of New York

The Geographical Review, Vol. XXVI, No. 3, 1936, Pl. II

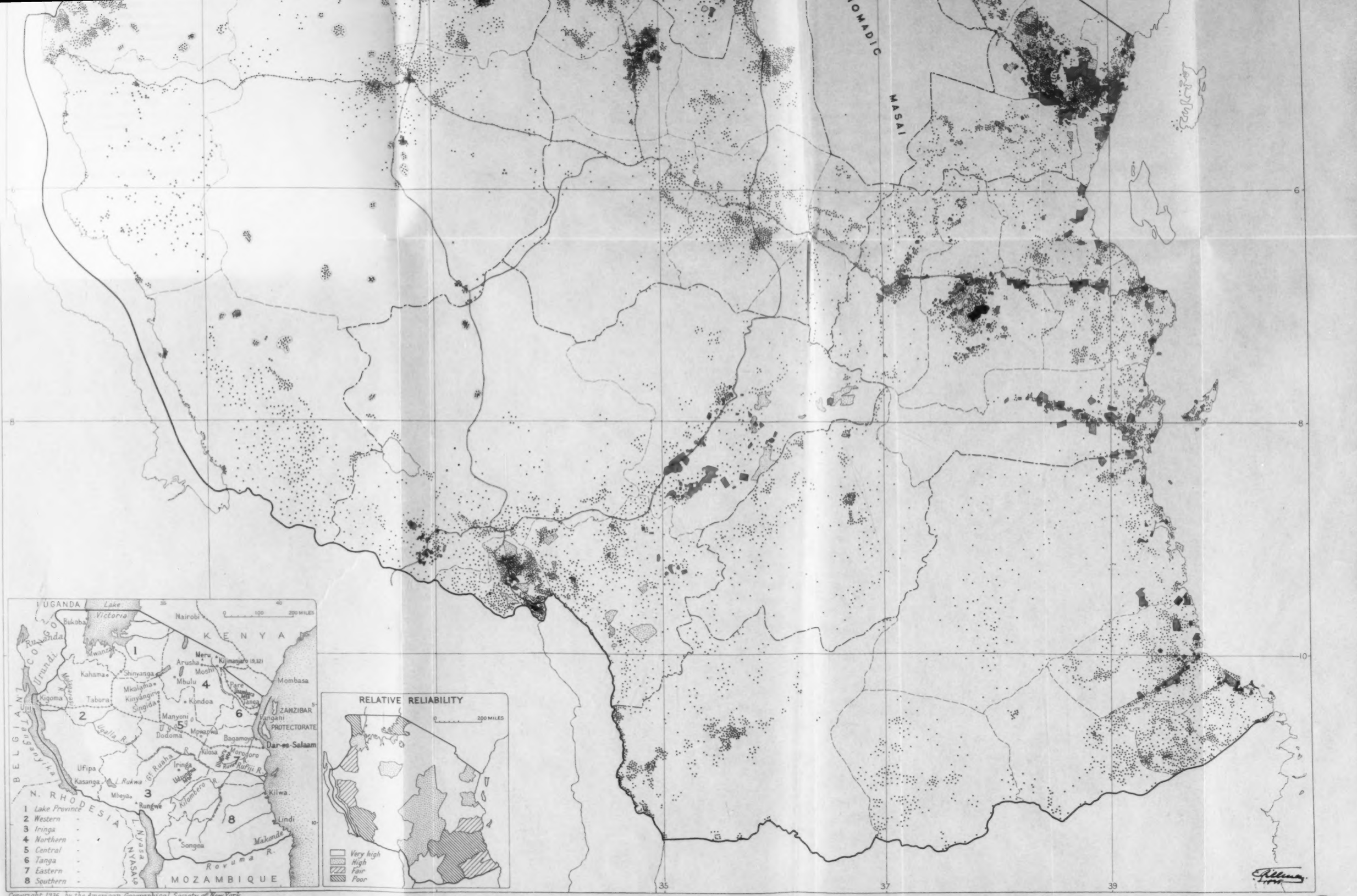
POPULATION MAP OF TANGANYIKA TERRITORY 1934

SCALE 1:3,000,000

0 50 100 MILES
0 50 100 KILOMETERS

Every 200 people represented thus
Every 50 people represented thus
Areas with a mean density exceeding 150 people per sq. km. (approx. 400 per Sq. mile)
Land alienated to non-natives
Forest reserves
Anti-sleeping sickness concentrations
Townships of over 4000 inhabitants
Territorial boundary
Provincial boundary
District boundary
Railways
Main roads

31
33
35
2
4
6
8
31.000
NOMADIC
MASAI



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UNIV. OF MICH.

the latest sheets of Africa, 1 : 1,000,000,[18] and into this framework the number of dots, computed from the figures given in the register, were fitted, with due regard for topography and other geographical considerations as far as the scale of the map permitted. The writer's personal knowledge of much of the country and of the settlement types helped very considerably to give reality to the pattern. In addition constant reference was made to a large number of maps,[19] many of which are not generally accessible.

Protracted experimentation determined the choice of a dot representing 200 people for most of the area and of an auxiliary open circle representing 50 people to utilize the sufficiently detailed data for one or two very sparsely populated districts, such as southern Kigoma. Owing to the chosen size of dot and the scale of the map, the dots began to run into one another where mean density reached 150 persons to a square kilometer (about 400 to a square mile). The few areas whose density exceeded this figure (Table II) therefore appear on the map as black patches. It may be of interest to research workers contemplating similar maps of other little-developed lands to know that the plotting of the dots occupied in the aggregate 146 working hours.

The few townships (see p. 370) with more than 2000 African inhabitants are represented by "spheres" with a radius proportionate to the cube root of the number of inhabitants, the standard-size dot for 200 people providing the scale.

To preserve the clarity of the pattern of dots, as few features as possible were added—provincial and district boundaries, railroads, and the main roads, existing or under construction. Reference should be made to the German 1 : 2,000,000 map ("Mittelafrika") of the Reichs-Kolonialamt, still the best available for general topography, as well as to the physiographical map of Teale and Harvey.[20] Table III gives a summary of area, population and mean density for each of the 8 provinces and 45 districts.

A comparison of the population figures used for the map with those published in the 1931 census shows a decrease for all the provinces except the Lake Province, the mean decrease over the whole Territory amounting to about 4 per cent. This is, of course, well within possible and—considering the difficulties of counting—permissible error and should not detract from the usefulness of a map designed primarily to give distribution pattern rather than absolute density. This remark holds good for the error introduced by the ratio of total population to taxpayers. A more serious source of error is the personal factor. Obviously, 45 district officers must differ greatly in length of service, acquaintance with the particular districts in which they happened to be stationed at the time the registers were compiled, general knowledge of African settlement types, and inclination to respond to the demands of the geographer. The relative reliability of different parts of the map depends less on the accuracy of the fundamental figures of count and taxpayer coefficient than on a combination of the personal factors of the collectors of data on the one hand and the compiler on the other. The inset reliability map is an attempt to classify the districts in accordance with such a combination and is based on the assessment of administrative information as sufficient (A) and insufficient (B) for a really good representation and the author's personal knowledge of the ground as either existing (I) or non-existing (II). By combination four reliability classes are obtained: A I, very high; B I, high; A II, fair; and B II, poor in which, as will be seen, greater weight has been attached to the compiler's personal knowledge. Uninhabited areas are included in A I. The four classes occupy the following percentages of the Territory's area: reliability very high, 55 per cent; high, 19 per cent; fair, 10 per cent; poor, 16 per cent.

[18] *G.S.G.S. 2465.*

[19] A copy of the list is on file at the American Geographical Society.

[20] *Op. cit.*

THE MARSHES OF PIŃSK*

Louise A. Boyd

FIG. 1

Dwellers on and among waterways are a folk apart from the general run of people, who have their feet planted on terra firma. In whatever part of the world they are found—primitive Uros of Lake Titicaca, Bakenyi of the papyrus swamps of Lake Kioga, Chinese of the Yangtze delta,[1] the Dutch on their polders—they have a cachet of their own. It is a difference that invites attention. For this reason, when I attended the Warsaw meeting of the International Geographical Congress in 1934, I seized the opportunity of visiting the country of the Pińsk marshes. One of my chief objectives in this, as in my other Polish journeys, was to obtain as complete a photographic record as possible of country and people.[2]

The area marked the "Marshes of Pińsk" on the map is roughly coincident with Polish Polesia (some 37,000 square kilometers), though this represents only half, and the smaller half, of the natural region of Polesia, the basin of the Prypeć stretching to the Dnieper.[3] This entire shallow depression is a country of forest and marsh, "flat and desperately monotonous." It is a region of ancient settlement, but man has modified the original landscape less here than elsewhere in western Europe.[4] All distribution maps of Poland reflect the relative primitiveness of Polesia—in the smaller population, the smaller amount of arable land, and the larger amount of forest, for instance.[5]

*Acknowledgment is gratefully made to the Polish government and Rear Admiral Swirski, commander of the Naval Flotilla of Pińsk, who put at my disposal a fast navy launch, manned by an officer and two bluejackets, and thereby enabled me to travel over a large area of the marshes, which otherwise would have been impossible.

Dr. Stanisław Gorzuchowski of the High School of Commerce in Warsaw and Dr. Wanda Rewienska of the University of Wilno accompanied me, and thanks are due them for their contributions to my understanding of this part of their country, where a knowledge of the Polish language is a necessity. One of the excursions of the Congress was made to Polesia, but the conflict in time did not permit me the opportunity of joining it (see footnote 4); however, Professor Stanisław Pawłowski, one of the directors, has kindly read the manuscript.

[1] Compare G. B. Cressey: The Fenghsien Landscape: A Fragment of the Yangtze Delta, in this number of the *Geographical Review*, pp. 396–413.

[2] The results will be presented in a *Special Publication* of the American Geographical Society, scheduled for appearance in 1937. All the photographs were taken by the writer.

[3] Emmanuel de Martonne: Europe Centrale (Géographie Universelle, Vol. 4), Part 2, Paris, 1931, pp. 667–668.

[4] Stanisław Pawłowski: Aperçu sur les paysages géographiques de la Polesie, *in* Polesie et Białowieża, *Congr. Internatl. de Géogr., Warsaw, 1934, Excursion A 1*, 1934, pp. 6–36, reference on p. 28.

[5] See, for example, Henryk Arctowski: Agriculture and Landownership in Poland, *Geogr. Rev.*, Vol. 11, 1921, pp. 161–171; and Eugene Romer: The Population of Poland According to the Census of 1921, *ibid.*, Vol. 13, 1923, pp. 398–412.

PIŃSK: CHIEF TOWN OF THE MARSHES

For my travels in this "unique corner" of Europe I made my headquarters at Pińsk, arriving there toward the end of September. This city of some 32,000 inhabitants (1931) is on an elevation at the east end of the peninsula of Pińsk, the Zahorodzie, a spur between the broad, marshy valleys of the Jasiołda on the north and the Pina and the Prypeć on the south. The distribution maps clearly reflect the importance of the Zahorodzie in greater density of population and amount of arable land.[6] Site and situation make Pińsk a focal point. The old land route between the Black and the Baltic Seas lay a short distance west of Pińsk; but most important for Pińsk have been the waterways.[7] The marshes have always constituted a barrier,[8] but they are not impenetrable. When the canals to the Vistula and the Niemen were cut in the latter part of the eighteenth century, Pińsk acquired a position of advantage. Grain, tobacco, and fats from the Ukraine went through en route to Danzig and Königsberg; Polesia itself shipped out timber and tar. Today one sees rafts of logs being towed by side-wheel steamers from points as far east as the Russian frontier to Pińsk, whence they are shipped by canal to the interior of Poland. But at the time of my visit, although Poland and Russia were on good terms, the frontier was closed to commerce, and strained relations between Poland and its northern neighbor, Lithuania, stopped traffic on the Niemen at the boundary.

Today Pińsk is accessible for motors—only in dry weather, however—by one through road, a dirt road running east from Kobryń. A wagon road goes northwest and connects with through routes. Knubowo, about 14 kilometers southeast of Pińsk, is connected with it by a road across a bridge over the Pina and is one of the few neighboring villages in direct communication with Pińsk. The city

[6] Halina Radlicz: Observations concernant le peuplement des départements de l'est de la République Polonaise (in Polish, with French résumé), *Rev. Trimestrielle de Statistique*, Office Central de Statistique, Vol. 11, 1934, pp. 279–297, with maps of absolute and relative population density and of arable land on the scale of 1 : 1,500,000; Edward Rühle: Utilisation du sol et répartition de la population en Polésie occidentale (in Polish, with French résumé), *Trav. Inst. de Géogr. de l'Univ. de Varsovie No. 14*, 1930, with maps of population density and land utilization on the scale of 1 : 500,000.

[7] To the Prypeć has been attributed one of the amber routes of antiquity. On this interesting topic Professor V. Gordon Childe writes us as follows: "The finds of amber in prehistoric graves or settlements associated with objects to date them are not sufficiently numerous in eastern Europe to make possible an accurate reconstruction of a trade route such as was produced by Navarro for Central Europe. Moreover, as there are amber deposits in the Ukraine, one cannot be sure that all the finds recorded are of Baltic amber and indicative of trade with that region. In my 'Dawn of European Civilization' I gave a map of the principal Neolithic and early Bronze Age finds from Poland and European Russia as recorded down to 1925. Even those finds sufficed, I think, to suggest intercourse along the Vistula into Galicia, and subsequent discoveries support that view. Though there may have been some extension of this intercourse to the Bug, I do not think the evidence suffices to establish anything like a regular through trade in amber between the Baltic and the Pontus, such as existed with the Adriatic."—EDIT. NOTE.

[8] Note, for instance, the strategic importance of the Prypeć (Pripet) marshes in the war world (D. W. Johnson: The Great Russian Retreat, *Geogr. Rev.*, Vol. 1, 1916, pp. 85–109). The airplane reveals the mazes of the marsh country; but only in the wintertime, when the waterways are frozen, is it passable from a military point of view.

FIG. 2—Village on the shores of Lake Horodyszcze.

FIG. 3—Wooden cross at T

FIG. 4—Fish nets drying at Horodyszcze.

Fisherman landing his catch.

is reached by one train a day in each direction passing between Warsaw and the Polish-Russian frontier. All other communication is still by water.

Travel by Water

The Polish part of the Prypeć marshes is patrolled by a fleet of small gunboats and speed craft of the Polish Navy. It was on a fast

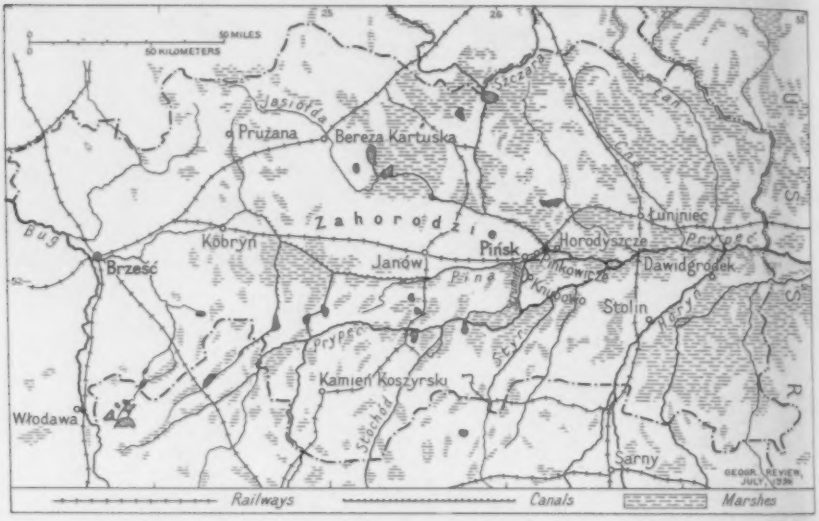


Fig. 6—Sketch map of Polesia showing the waterways about Pińsk. Note the canals—the Royal Canal connecting the Pina with the Bug and Vistula and the Ogiński Canal connecting the Szczara and Niemen with the Jasiołda. Scale of map approximately 1 : 3,000,000. Based on Romer and Szumański's relief map of Poland in altitudinal tints on the scale 1 : 1,250,000, Książnica-Atlas, Lwów, 1932.

navy launch that I went out into the marshes and returned at night. Inns or lodgings of any kind are unknown in the marshes, and it would otherwise have been impossible to travel beyond a day's distance by boat from Pińsk except by the side-wheel steamers. These carry passengers, freight, and mail on a regular schedule on the larger canals, but they would have permitted no opportunity of visiting the settlements.

The marshes are commonly described as flat and monotonous in the extreme, but I did not find them so, possibly because my chief interest lay in the human element. In the fisherfolk and the several kinds of fishing, the many kinds of nets and other equipment, the different settlements and farm practices, in the differences among the people themselves—White Russians, Ruthenians, Poles, and Jews meet here—and in the kaleidoscopic scene of the big Pińsk market I found variety in plenty.

The first impression made on me by the marshes was of their great silence—a silence broken only by the occasional swish of canoe paddles

or the rare whistle of a steamer. How different from the noisy journey through the ice-ridden fiords of Greenland![9] At the sound of our launch, horses being transported by canoe from one plot of farm land to another would bolt overboard into the canals and dash for land, towing the boats behind them, with an alacrity equal to that displayed

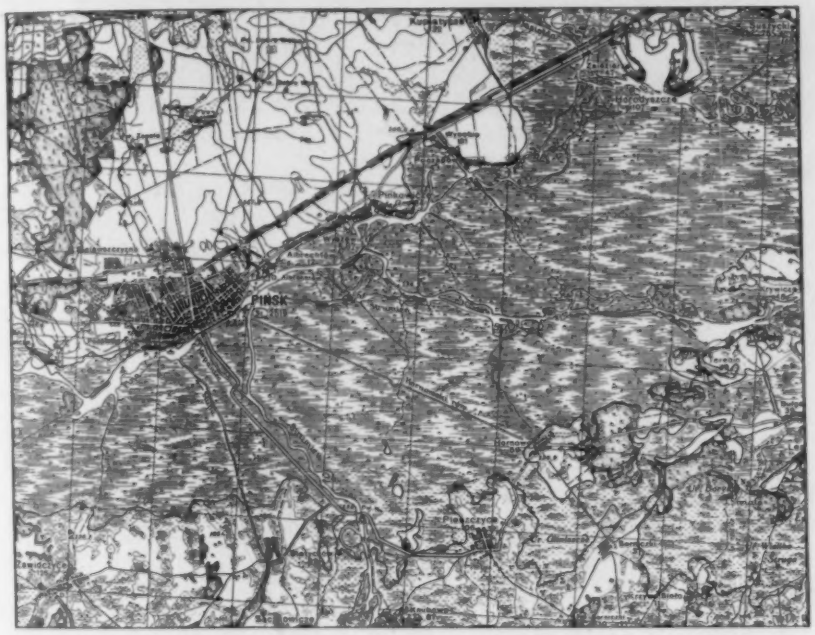


FIG. 7—Map of an area about Pińsk on a scale of approximately 1 : 175,000. Reproduced from the Pińsk sheet of the standard topographic map of Poland 1 : 100,000, by permission of the Military Geographical Institute of Warsaw. Note the site of Pińsk on the relatively elevated Zahorodzie (see Fig. 6) and the typical examples of anastomosing channels in the marshy riverine plain. Lake Horodyszcze is unshaded.

by their confreres on land at the sight and sound of my automobile! Birds populate the marshes in great abundance. Wild ducks and geese from the north come and remain all winter, and Polesia is known as the hunter's paradise. Yet at this season of the year even the birds, whose "joyous calls resound all summer," are silent. And this great silence of nature extends to the people, who, while poling their canoes, combine with their labors no merriment of laughter or song.

Hand-hewn, flat-bottomed boats ply the waterways. In places the canals are so shallow as to permit the use of nothing but flat-bottomed boats. They range in size from those suitable for individual use and for carrying small quantities of farm produce to large freight barges. They are propelled by poles about 15 feet long, with a flat blade used for paddling in the wider and deeper waterways. Very

[9] L. A. Boyd: Fiords of East Greenland, *Geogr. Rev.*, Vol. 22, 1932, pp. 529–561.

FIG. 8—Pińsk seen from the southeast. The Jesuit Church on the left.

graceful is the movement of the fishermen and women as they appear and disappear in the maze of waterways. On the larger canals red and white markers serve as guides to deep water. But only the instinct with which these people are born, who for generations have known no other abode and no other horizon than these marshes, enables them to find their way among the myriad uncharted waterways hidden in high grass and bushes.

FISHING A CHIEF OCCUPATION

The marshes are well supplied with fish,[10] and fishing is naturally a main support of the population. It is carried on from the flat-bottomed boats, manned by one or two men, who pole their way through seemingly impenetrable marsh vegetation. Where the water is visible, it is so still that the fishermen and their canoes are perfectly reflected. Several kinds of nets are used. One is a large, conical net, four or five feet high, composed of three wooden rings connected by mesh. This net is submerged large end down several feet below the surface of the water. The fisherman pokes into the reeds with his long pole and drives the fish into the net, which is then tilted and brought to the surface. Other nets are oblong and are composed of a succession of inside traps and small rings connected with netting of coarse string.

When the day's fishing is over, the oblong nets are attached to poles and dried in a horizontal position along the banks; small nets are dried upright; and the conical nets are placed right side up over bushes, along the edge of the more accessible waterways if possible. One cannot help but be surprised at the way the fisherman can, on sight and without stopping to examine them, identify his own nets. It is all of a piece with the ability and accuracy with which these fisherfolk navigate the maze of waterways without compass or marker.

[10] According to Professor Pawłowski the Polesian fishermen distinguish some forty species of fish, of which the most widespread is the mudfish. Some species ascend the Dnieper from the Black Sea; for instance, the rare Black Sea herring (*Clupea pontina*), the sturgeon, and the sterlet. The tortoise should not be overlooked.

FIG. 9—Raft of birch logs at Pińsk: eastern part of the town in the background.

The fish caught seem to be used for local consumption only and to be used fresh: as far as I could ascertain, no attempt is made at salting, drying, or smoking, even though birchwood, so well suited to smoking, is available in quantity. This is in marked contrast with what I have noticed in the northern countries of Europe.

MARSH VEGETATION

The natural vegetation of the marshes is no less important in the economy of the marsh people. Marsh grass, coarse in texture and flat, grows to a height of several feet throughout the marshes. It is harvested during the summer and early autumn, by men who stand for the purpose in water and mud up to their knees. It is cut by scythe and stacked on a basketwork foundation of branches. During the summer some of the stacks may be carried by boat to the farms, but the greater number remain along the canal banks. The grass furnishes bedding for the farm animals and sometimes is used for thatching. The commoner thatching material, however, is the hollow-stemmed marsh reed.

Volunteer hay from the marshes is likewise stacked along the canals during the summer and early autumn for use as fodder. In winter, when the marshes are frozen solid, hay and grass are brought to the villages by horse and sleigh. Dairy cows are grazed along the canal banks. After milking they can often be seen swimming across the canals.

Willow grows abundantly in the marshes. Generally it is of low habit, with slender trunk and branches. This, too, is harvested for manifold purposes. The leaves are removed and the twigs dried and put away. When needed they are softened by being soaked in water until they are pliable enough to be woven into all kinds of basketwork —fishing baskets, linings for farm wagons, and for the walls of granaries, where the advantage of such a wall is that it permits the passage of air. Interwoven willow twigs make the common type of fence seen throughout Polesia, fencing farms and fields and corrals.

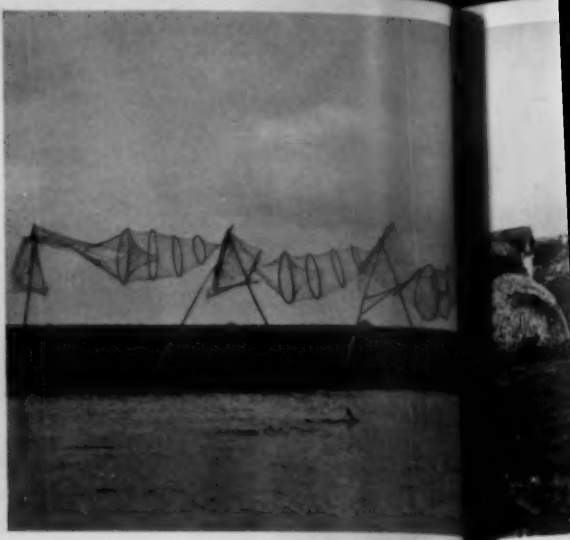
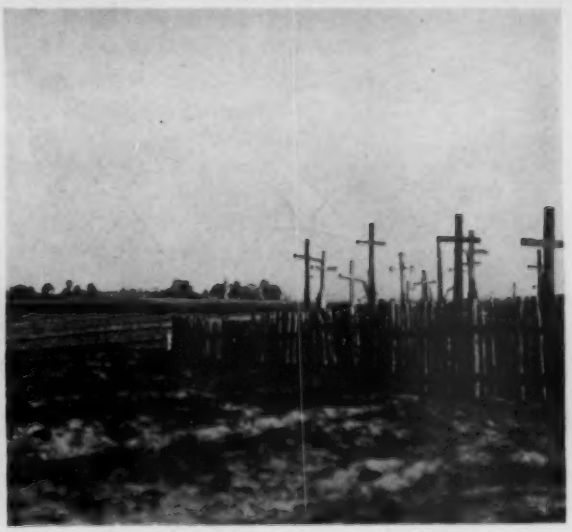


FIG. 10—Stack of marsh grass along the Jasiołda River.
FIG. 11—Barge with birch logs approaching Pińsk.
FIG. 12—The farmer uses a canoe to go from one patch of his land to another.

FIG. 13—Fish nets at Pinkowicze. Strumień River.
FIG. 14—Cutting marsh reeds at Pinkowicze.
FIG. 15—Canoes laden with marsh grass.



16—Houses in Horodyszcze: wood with thatched roofs and chimneys.

17—An Orthodox Greek church.

18—Houses in Kuradowa: note white trim to windows and fences.

FIG. 19—Gateway to village of Tupczycze: note fish box and nets drying on fence.

FIG. 20—Farm buildings at Knubowo: rough-hewn walls and rye thatch; well on right.

FIG. 21—Cemetery at Tupczycze: village in distance.

FIG. 22—Close-up of barn at Pinkowicze: fish nets, melons drying.

Pine trees grow in small stands on some of the islands and furnish a certain amount of wood for local use.

THE HYDROGRAPHIC YEAR

It is difficult to define the hydrographic regime of this lacis of waterways that constitutes the Prypeć basin or to make precise measurements of depth or flow. As the State Hydrographic Service observes: "Nowhere else does one find watercourses so rich in polyfurcations and branchings, a flow so profoundly influenced by the aquatic vegetation, inundated terrain of such extent, contours so indecisive."[11] Flood stage usually occurs in March or April, low stage in September or October. The hydrographic year is dated from November 1. Often by November, surely by December, the waterways are frozen, and boat transportation is replaced by sleigh. Bitter winds from the Russian steppes howl through the marshlands and make the winters extremely severe. Spring does not appear until May, sometimes early June.

THE FARM VILLAGES

The breadth and depth of the rivers vary; during the flood season the flow may be increased 10 to 15 times and the waters spread over vast surfaces. Settlements are built above the high-water mark on the elevated banks of the watercourses or on terraces or on the sandy islands (dunes) so common a feature of Polesia. Except for the occasional fisherman's hut and the isolated settlements called *futory*,

[11] Résultats des jaugeages exécutés dans le bassin de la Prypeć au cours des années 1922–1931 (in Polish, with French résumé), Ministère des Communications, Service Hydrographique de l'État, Warsaw, 1934, p. 100. See also "Le régime d'écoulement de la Prypeć a Mosty Wolańskie" (in Polish, with French résumé), Service Hydrographique de l'État, 1933; and Tadeusz Zubrzycki: Le régime hydrologique de Poléssie polonaise (in Polish, with French résumé), *Rev. Polonaise de Géogr.*, Vol. 14, 1934, pp. 99–123.

the population is concentrated in compact villages of 100 to 2000 inhabitants, usually of the *strassendorf* type. As Pawłowski remarks:[12] "The Polesian peasant is so deeply attached to his single-street village that even the frequent conflagrations do not discourage him from building in this form of close-set houses along a street. The Polesian plain favors this type of agglomeration, thanks to its configuration, and sometimes the villages are strung along for two or three kilometers. In such a village the process of dispersion is accomplished slowly, with many objections on the part of the inhabitants."

FIG. 23—Woman cleaning and beating flax; melons ripening on window sill: note wide hand-split logs in house wall.

Houses and other buildings, farm tools, and equipment are largely of wood; indeed, the Polesians may be said to be living in a "wood age."[13] Roofs are thatched with hollow-stemmed reeds, flat marsh grass, or rye straw. Close contiguity and inflammable structure make the fire hazard serious. One is constantly reminded of it by the ladders placed against the house walls, a custom found elsewhere under similar circumstances.[14] Long poles are also within easy reach, some with a brush of twigs on one end, for beating out fire, others with a large iron hook for pulling the burning thatch from the roof. The new agrarian-reform laws seek to disperse these crowded villages and at the same time bring about a better redistribution of the landholdings, held in many scattered fragments. It is a common sight to see horses,

[12] S. Pawłowski: Recherches sur l'habitat rural en Pologne, *Comptes Rendus Congr. Internatl. de Géogr., Paris, 1931*, Vol. 3, Paris, 1934, pp. 244–249; reference on p. 248. See also Bogdan Zaborski: Sur la forme des villages en Pologne et leur répartition (in Polish, with French résumé), *Prace Komisji Etnogr. Polskiej Akad. Umiejętności No. 1*, 1926.

[13] "Polesie et Białowieża" (*op. cit.*, see footnote 4). For a plan of a typical farmhouse and other details see Giorgio Pullé: La Polesia polacca, *L'Universo*, Vol. 16, 1935, pp. 213–242. This is a narrative of the excursion to Polesia of the International Geographical Congress by one of the participants.

[14] See, for example, D. H. Davis: The Finland Community, Minnesota, *Geogr. Rev.*, Vol. 25, 1935, pp. 382–394.

FIG. 24—Courtyard of house in Pinkowicze: melons drying on barn roof; woman mangling flax.

plows, wagons, and other equipment being transported by boat from one piece of property to another. Everyone owns his own property, and wooden pegs along the canals are used as property markers. People measure their property in *sznury*, "rope." Instead of counting in hectares or acres, they say, "I have so much *sznury*."

One-horse plows are in general use. Harrows are made entirely of wood, even the pointed spikes being of wood laced together with twigs. During my stay in the marshes I never saw oxen used to haul wagons or draw plows.

MARSH SETTLEMENTS SELF-SUFFICIENT

For the most part the population of the marshes is self-sufficient. Flax is grown and woven by the women. One sees large bundles of it near the barns or drying upright against the walls. It is prepared in various ways; in the simplest method the flax is laid over a hollow log and beaten with a flat club. Sheep supply the wool for the warm homespun winter clothing. In the chilly days of early October many people wore their sheepskin coats and hats, homemade of course.

FIG. 25—Stack of rye straw on stilts at Pinkowicze. Note the cross on top.

Stacks of rye straw and of the volunteer crops cut in the marshes are piled, usually in circular form, in the barn enclosures or in the fields, raised three feet or so off the ground on wooden piles. They are fastened down with fish netting and sometimes are capped by a small wooden cross.

Hardy vegetables—chiefly potatoes, cabbages, carrots, and beets—and melons are grown in sufficient quantities for local needs. Potatoes are kept under a cover of sod and thatch for winter use. Rye furnishes the bread. A cabbage leaf is placed on the under side of the loaf to prevent the dough from sticking to the oven.

FIG. 26—Granary in Knubowo: walls of woven twigs, roof of rye thatch; against the wall wooden harrow, steel plow, and basket lining of farm wagon.

The hogs are a lean, tall-standing black or black-and-white breed. Together with chickens, ducks, and geese, they are raised in all the settlements. Combined with fish these products make the people self-supporting, save for a few staples such as coffee, tea, and sugar, which must be bought from the distributing point, Pińsk.

The settlements obtain their water supply from shallow wells (2 to 4 meters deep), with a well sweep (*żóraw*) in the form of a long pole balanced in the crotch of a forked tree. Women launder their clothes in the cold waters of the canals, beating the clothes with a wooden paddle on flat stones.

Numerous Children in the Villages

Children swarm in all the villages; one appreciated the fact that Poland is increasing its population at a greater rate than any other country of western Europe[15] and that Polesia has the highest birth rate of the Polish

FIG. 27—House of rough-hewn logs with reed thatch roof. Flax, stacked upright, is drying against the walls.

[15] Mark Jefferson: The Growth of Europe's Population and an Estimate for 1936, *Geogr. Rev.*, Vol. 26, 1936, pp. 148–149. See also Vladimir Kubijovyč: Le mouvement de la population en Pologne dans la période 1921–1931, *Le Monde Slave*, 10th Year (N.S.), Vol. 1, 1933, pp. 441–454. The average annual birth rate of Polesia for the period was 4.49 per cent, as against 3.44 per cent for Poland as a whole. The natural increase of population in Poland, 1930–1934, was 13.9 per mille; in Germany (1933) it was 3.5, in Italy, 10.1.

FIG. 28—Farmlands at Kuradowa with stacks of feed and bedding on stilts.

provinces. Most of the children of the villages were barefooted, poorly clad, and dirty, but all looked healthy and happy. Babies were swung in baskets of birch twigs, which serve as cradles and are hung on the house walls. Small canoes, manned by children of tender age, served as carriages for these water babies. Each child seemed nurse for a younger one. These fishermen and women of the future handled their small craft with easy assurance, just as much at home in them as on land.

Illiteracy has prevailed throughout the region until recently. Since the area became part of Poland education is compulsory, and schools are maintained throughout the marshes. In places children have miles to go to school, and their illiterate parents frequently fail to coöperate with the authorities.

Old men and women often appeared crippled with rheumatism, and an absence of many old people was noticeable.

Where the topography permits, the cemeteries are on high ground close to the villages. Most of them are enclosed by unpainted wooden fences, some of them by barbed wire. Logs cover the graves, which are surmounted by unpainted wooden crosses without name or identification—a reflection of the prevalent illiteracy. The many small crosses indicate a high death rate among the children. No care is given to the cemeteries; but once a year, in Easter week, the people go there to tie hand-woven linen on the wooden crosses and eat hard-boiled eggs by the gravesides.

THE PIŃSK MARKET

The visitor to Pińsk is reminded that eastern Poland is a country of mixed population—in language, race, and religion. Russian influence is evident throughout the marshes, and most of the people belong to the Orthodox Church. The Roman Catholic cathedral dates from 1396. An imposing baroque building erected in the latter part of the seventeenth century is the church and college of the Jesuits,

FIG. 29—Oxen on the road from Brześć to Pińsk.

in the market place. The church of the Dominicans, also baroque, dating from 1810, is now the Orthodox cathedral. Jews also form a large element of the population. The first few days of my stay were Jewish holidays, and, as most of the trading is in the hands of Jews, practically all the stores were closed. The great market square was empty. The water front, where the market barges land, also was devoid of interest.

In striking contrast was the scene on October 3, when the big monthly market was held. I have visited markets in many countries, but nowhere else have I seen so unique and interesting a sight as the Pińsk market. It is the focal point at which people who live miles apart meet, sell their wares, greet one another, and partake of refreshment—tea, beer, or vodka (distilled from potatoes)—in the small cafés. Market day is, in fact, a fete day.

For several days before boats arrived laden with produce. The canals took on a new life. Many of the people travel between 15 and 20 miles. Everything that could transport by water was beached along the Pina River on the south side of the church of the Jesuits. Many who came by boat slept in their craft while in Pińsk; wagons served the same purpose for the travelers by land.

By 7.00 a. m. of October 3 the market was in full swing. As in markets throughout the world, the Pińsk market was systematically divided into sections. Facing the north wall of the church were the wagons with wood and lumber—birch logs, held in place on the wagons by wooden droshky yokes similar to those used for harness, sawed planks, wood for shingles, twigs for baskets, fences, and firewood. Near by were the wooden wares.

On the west side were poultry, vegetables, and fruit—apples, pears, and a few grapes and bananas. The street along the west side of the church was reserved for wagons with hay, including marsh grass and reeds. Hay, when sold, was weighed by an official weigher. Down the hill came wagons loaded with hay, the drivers yelling and

FIGS. 30 to 35—Scenes at the Pińsk monthly market, October 3, 1934.

FIGS. 36 to 41—Scenes at the Pińsk monthly market, October 3, 1934.

colliding with one another because of poor brakes on the wagons. There was hardly room to move. I counted nearly 300 of these wagons.

The water front on the south side of the church was occupied by everything brought by boat. Fish were sold from the boats and carried around on strings. All available space was taken by boats pulled up on the shore—boats of all kinds and containing a variety of produce. Parallel to the water front is the main artery by which most of the wagons entered the market. The east side seemed the place for the general overflow, and miscellaneous goods were for sale there.

Most of the horses were old, lean, and exceedingly dilapidated of harness. The wooden droshky yoke was in common use. I was told that this was preferred to the one-pole and leather collar and rope harness used elsewhere in Poland. Farmers brought whole wagonloads of geese to market. They lay in dozens on the pavement, their feet tied so that they could not get away. Chickens were treated the same way or were kept in improvised wire coops. Large white hogs tied down in the wagons were a common sight. Calves also came this way. Live sheep were carried on the backs of their owners.

Delicious-tasting mushrooms, of which there are such quantities in the woods of northeastern Poland, were sold from willow baskets or carried in strings (see Fig. 37, lower left) like the garlic (see Fig. 36, upper left.) Eggs and potatoes were on the market in great abundance.

One saw peasants of all kinds and types. Costumes were generally similar. Most of the men wore trousers of linen or homespun woolen material and hip-length jackets or full-length coats of woolen material or sheepskin. Some were barefooted; others wore birch-bark sandals over cloth leg wrappings that took the place of socks (nowhere did I see women knitting socks or stockings); high leather boots, on sale in the market, were worn by the more prosperous. Hats were usually of felt or black sheepskin.

The women were mostly dressed in homespun or bright cotton print bought in Pińsk or a dark material of solid color. Many of them wore large plaid shawls. Homespun linen aprons were much in evidence. Many of the women were barefooted; some wore birch sandals, others the knee-high leather boots, some high shoes. Like the men, they had sturdy physiques and a direct and friendly manner.

The Pińsk market may be said to provide an epitome of the life of the marshes. It reveals the importance of Pińsk as the natural capital of the region. We may recall that the city has long served as a market for a larger or a smaller area. Up to the Polish insurrection of 1863 its great fairs were frequented by merchants of Kiev, Wilno, and Warsaw.[16]

[16] "Polesie et Białowieża" (*op. cit*), p. 78.

Two things should make for the growth of Pińsk—exchange of relations with its Soviet neighbor and the development of the region itself that will come with the reclamation of the marshes, a project of the Polish government now under way. We have lately seen the accomplishment of two remarkable works of reclamation in Europe—the draining of the Zuider Zee and of the Pontine Marshes. But the task before the Bureau for the Drainage of Polesia is more formidable. It seems likely to be a long time before the wild solitudes of the marshes of Pińsk are turned into fertile fields and one more primitive landscape becomes merely a historical fact.

TABLE I—SUMMARY OF THE PRICES AT THE MARKET IN PIŃSK
(1 zloty = 100 gross = 20 cents U. S. A. in October, 1934)

Domestic ducks	1.50 zl. a pair	Butter	2.50 zl. a kilo	Pigs	120 to 140 zl.
Geese	2 zl. each	Bread (loaf)	25 gr. to 1 zl.	Beef and veal	1 zl. a kilo
Mushrooms	1 zl. a kilo	Buns (large)	5 to 10 gr. each	Pork	70 gr. a kilo
Chickens	2.50 zl. a pair	Wood (birch)	7 zl. for 1 sq. m.	Apples	30–50 gr. a kilo
Fish	25 gr. a kilo	Garlic	50 gr. a string	Pears	30–50 gr. a kilo
Eggs	50 gr. for 10	Sheep pelts	40 gr. each	Beets	5 gr. a kilo
Large melons	20 gr. each	Live sheep	12 to 20 zl.	Potatoes	3 gr. a kilo
Cabbage	5 gr. each	Calves	20 zl.	Cranberries	10 gr. a kilo

THE FENGHSIEN LANDSCAPE: A FRAGMENT OF THE YANGTZE DELTA*

George B. Cressey
Syracuse University

TWENTY miles south of Shanghai, near the edge of the growing Yangtze delta, lies the crowded county of Fenghsien. On one side is the ocean, from which the land has persistently been snatched. On the other is the exotic metropolis of Shanghai,[1] singularly out of harmony with this ancient agricultural countryside.

Above Fenghsien fly the planes of the air service from Shanghai to Canton. As viewed from the air, the most striking features of the flat, green landscape are the micropattern of the fields and the net of closely spaced canals. Other areas may have an equal intensity of agriculture, but in few parts of the world is there a similar development of canals and ponds. In one measured square mile there are no less than 27.8 linear miles of these waterways, and the average spacing is only 380 feet.[2] It is these that give the area its distinctive stamp and make the *geo*graphy essentially *hydro*graphy.

From the air one may see the lines of maritime dikes bordering the silt-laden sea, which protect the land from high tides. These barriers enclose successively reclaimed areas similar to the Dutch polders. Within the newer dikes the canals are laid out in rectilinear plan, in contrast with the irregular pattern in the older land, west of the innermost, and older, dikes. Scattered clusters of broadleaf trees and bamboo surround groups of farmhouses, and one is seldom out of sight of a market town.

Flagstone trails take the place of roads, for there are no carts and few wheelbarrows. Passenger and freight boats move slowly along the larger waterways; smaller farm boats carry fertilizer or produce over the smaller canals. Outside the dikes, along the shore, are numerous salterns, where thousands of evaporating trays are spread out.

But the full intensity of land use is not to be understood from the air. One must descend, perforce by parachute, for there are no fields large enough to set down a plane. Grave mounds, rising to eight or ten feet, provide the best vantage points. Tall reeds hide many of the canals; but on all sides there are garden-like fields, covered in summer with cotton and rice and in winter with wheat and broad beans. There are no fences, and field boundaries are mere ridges

* Based on field work during July and August, 1934, supported by grants-in-aid from the National Research Council of Washington and the National Agricultural Research Bureau of Nanking.

[1] See J. E. Orchard: Shanghai, *Geogr. Rev.*, Vol. 26, 1936, pp. 1–31.

[2] See map, Figure 139, in G. B. Cressey: China's Geographic Foundations, New York and London, 1934. p. 285.

among the flooded fields. Farmsteads and canals cover as much as a quarter of the area; grave mounds occupy from five to ten per cent of the arable land.

Even from the highest graves there are few broad vistas because of the trees and bamboo which half hide the scattered farmsteads. Along the canals are thatched shelters for the irrigation pumps. The innumerable grave mounds betray the long past; the numberless cheerful children suggest problems for the future. With a rural population of 2000 to a square mile there can be little idle land and but infrequent cessation in man's supreme occupation—the quest for food.

The Fundament

If we could sweep aside the cover of vegetation and the structures of man, the vicinity of Fenghsien would present a monotonously flat sky line. No part of the area is now more than twelve feet above sea level (Woosung Horizontal Zero).[3] But for the intervention of man, the delta would be crisscrossed by random drainage ways, most of them tidal thoroughfares. The mean tidal range at Gutzlaff outside the Yangtze estuary is 10 feet, and in the narrow part of Hangchow Bay the range exceeds 20 feet. During high spring tides and onshore typhoon winds all the region would be inundated. After each of these occasional invasions of muddy Yangtze water an increment of silt would veneer the area. Well borings at Shanghai have penetrated 920 feet without reaching the bottom of the delta.[4] The Yangtze today carries an annual burden of silt and clay amounting to 494,000,000 tons, which is spread out over the floor of the East China Sea. Measurements in Hangchow Bay by the Whangpoo Conservancy Board show an average silt content of 1000 parts in a million, by weight. Changing shore currents influence the areas and rate of accretion, so that the boundary between land and sea varies with the size and slope of the submarine delta. Von Heidenstam[5] estimates a shore-line advance of one mile in 60 years, but it is clear that the distribution of land and sea has been and is influenced by both erosion and deposition. This is the foundation that man has reclaimed so completely that there are no longer natural drainage ways.

Fenghsien is a humid subtropical land with monsoonal tendencies (Köppen's Cfa), somewhat similar to the southeastern United States. The winter brings occasional freezing temperatures and a flurry of snow, but the ponds rarely have more than a paper-thin coating of

[3] H. von Heidenstam: Report on the Hydrology of the Hangchow Bay and the Chien Tang Estuary, *Shanghai Harbour Investigation Repts.*, Ser. 1, No. 5, Whangpoo Conservancy Board, Shanghai, 1921.

[4] G. B. Cressey: The Geology of Shanghai, *China Journ.*, Vol. 8, 1928, pp. 334–345; Vol. 9, 1928, pp. 89–98.

[5] H. von Heidenstam: The Growth of the Yangtze Delta, *Journ. North-China Branch of the Royal Asiatic Soc.*, Vol. 53, 1922, pp. 21–36; reference on p. 26.

ice. Most of the rain falls during the summer, but every month has at least two inches of precipitation; the yearly average is 45 inches. The growing season is more than 300 days. Summer temperatures are high, and there is much humidity. Statistics for near-by Shanghai from 1873 to 1930 show that during July the mean temperature is

FIG. 1—Map showing the situation of Fenghsien in the Yangtze delta and in relation to Shanghai (the International Settlement, French Concession, and old walled Chinese city are closely ruled; the shaded border marks the limits of Greater Shanghai). Scale approximately 1 : 1,000,000.

The main maritime dikes are shown with date of construction, from the Whangpoo Conservancy Board's "Sketch showing the historical conditions of the Chien Tang Estuary and the northern shore of Hangchow Bay" (see footnote 3).

The rectangle from the Whangpoo to Hangchow Bay (dashed line) shows the area covered by the Whangpoo Conservancy Board's plane-table survey of 1920 on a scale of 1 : 6000. The survey was undertaken when the board had under consideration the excavation of a new channel to replace the Yangtze entrance to Shanghai: The project was however dropped in favor of dredging the Yangtze bar and the map has not been published: two representative portions (the small ruled rectangles) are reproduced on a reduced scale in Figures 2 and 3.

98° F. and the relative humidity 84 per cent; in January the mean temperature is 21° F., and in December the relative humidity is 76 per cent. During the summer of 1934 Shanghai experienced 21 consecutive days during which the daily maximum was more than 100° F., and for 60 days the daily maximum averaged 97° F.

No trace remains of undisturbed natural vegetation. Many temple courtyards and ancestral burial plots contain large specimens of pine (*Pinus Massoniana* and others), cypress (*Cupressus funebris*), ginkgo, elm, and oak. Farmsteads are invariably shaded by fir (*Cunninghamia lanceolata*), pine (*Cryptomeria japonica*), cinnamon (*Cinnamomum japonicum*), and broad-leaved forms such as camphor and candleberry; and scattered trees are found along the canals and in the fields. Groves of bamboo are common. Wood is rarely used for fuel, and the local supply of lumber is inadequate for house, furniture, and boat construction. Reeds on the canal banks and grasses on the grave mounds furnish fuel and forage; straw is used for fuel, rope, sandals, and thatch.

The soils of Fenghsien reflect their alluvial origin and the centuries

of exploitation. Mechanically the soil is a silt loam, fine enough to permit flooded rice fields to retain their water for several days, according to the weather. From the ocean inland to the Whangpoo there is a steady gradation from coarse to fine and from light to dark. In the newer soils of the polders there is little humus, and the salinity is high enough for a white efflorescence to form on all ridges. No mature soil profiles were found anywhere in the region. During the centuries of utilization, several thousand crops have been taken from the fields. As agricultural practices involve using the straw and sometimes even the roots for fuel or other purposes, there is a large drain on the resources of the soil. Were it not for repeated and painstaking application of canal muds, compost, and human wastes, crop yields would be low.

Dikes and Canals

In this ancient and intensely human land the present landscape patterns are unintelligible without an appreciation of the succession of past cultures. Fortunately the major outline of the record is available. Fenghsien, in common with most other counties of China, has an official gazetteer containing information on geography, political changes, famous people, and economic conditions—a valuable aid in reconstructing the succession of landscape changes.[6] Twenty miles southwest of Fenghsien city a large river formerly emptied into Hangchow Bay, possibly a mouth of the Yangtze or at least a continuation of the upper Whangpoo River. Before 1050 the discharge of fresh water was so great that the bay was also fresh. After this date the flow lessened and the bay became brackish, so that locks were constructed at the mouth of the river to prevent inflow. By 1471 the passage was completely closed and the flow reversed to the present Whangpoo.

The official construction of sea dikes seems to have been begun in 721 A.D. Little is known about the location of earlier dikes, but the records indicate that in 1171 the dikes southwest of Fenghsien city were constantly being shifted inland. It is not possible in this paper to trace the long record of construction and erosion, but it may be mentioned that the main dike, which passes near the wall of the city of Fenghsien, apparently dates from 1471. It is made entirely of earth and has a height on the inner side of eight to ten feet and a width on top of some fifteen feet. The land on its seaward side continued to receive flood silts after its construction, so that the land level outside the dike is commonly two to four feet above that inside. In front of this main dike are four other dikes in a distance of three and a half miles. The outermost, a mud wall five feet high, is being

[6] The Fenghsien District Record, 20 chapters in 6 volumes, was compiled in the twentieth year of the emperor Ch'ien Lung, 1756, and was republished in 1878.

undercut by storm waves and is in disrepair. This foreshore has been reclaimed as rapidly as deposition has taken place, but its agricultural utilization is handicapped by the salinity of the soil. In 1633 the land was reported to extend from one to four miles, widening eastward, and was classed as the dry, the medium, the wet, and the alluvium.

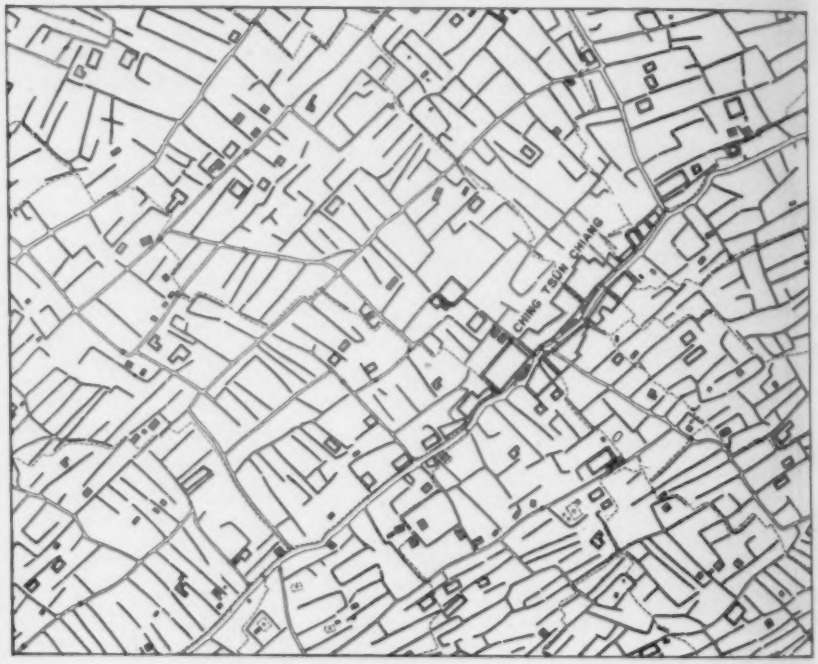


FIG. 2—Map on a scale of approximately 1 inch to 2000 feet of a representative area in Fenghsien *hsien*. Chingtsunchiang (see also Fig. 19) is some four miles west of Fenghsien city. Canals (double lines), bridges, paths (dashed lines) and houses and other buildings (defined by hatching) are shown. The map is reduced from the Whangpoo Conservancy Board's plane-table survey of 1920 on a scale of 1 : 6000. See Figure 1 for position and orientation (the top of the map is northeast).

By 1878 the foreshore east of Yangtze Cape had grown out six additional miles.

Several lateral dikes connect those parallel to the shore and divide the reclaimed areas into polders. In the outer polders ground water is still too saline for drinking, and farmers must carry fresh water a mile or more. The water problem in the polders is primarily one of drainage. Rice is not grown, partly because the soil in the paddy fields is too sandy to hold water and irrigation pumps are lacking. The newness of the area is betrayed by the planned pattern of parallel drainage ditches and right-angled laterals. Since the surveys of the Whangpoo Conservancy Board in 1920 a large additional polder has been ditched. Residents in this new area report that there has been some cultivation since 1915 but that all houses have been built since 1920 or 1925.

Along the sea there now extends a continuous series of maritime dikes from Hangchow around the mouth of the Yangtze and up the Whangpoo River. All drainage inside the main dike thus reaches the sea by way of Shanghai. Surplus water in the outer polders drains directly to the sea through sluice gates at low tide.

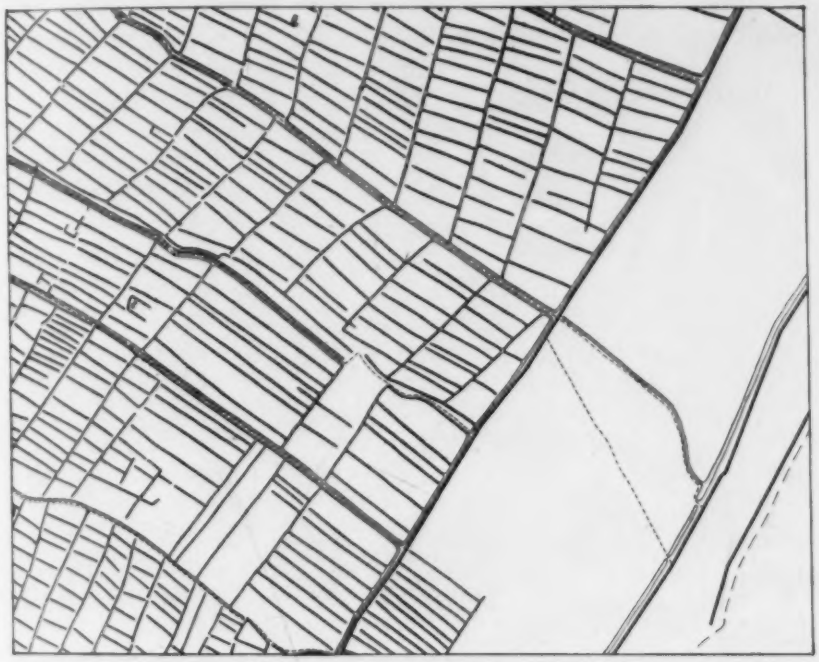


FIG. 3—Representative area of land most recently reclaimed on the Fenghsien shores of Hangchow Bay (Whangpoo Conservancy Board's survey). Scale approximately 1 inch to 2000 feet. Compare with Figure 2 and note the planned regularity of the canal net and the lack of habitations (only one house is seen). See Figure 1 for position and orientation (the top of the map is northeast).

The tidal movement through the canals varies considerably in height and velocity from place to place. Near the Whangpoo there is a range of four to six feet, and the current in the main canals makes it necessary for boats bound in the opposite direction to tie up along the bank. The discharge of fresh water by the Yangtze is so great that the incoming tide is never brackish. That there is some dependence on ground water was demonstrated during the protracted drought in the summer of 1934, when many of the smaller canals were nearly dry and the depth of water in others was so reduced as to hinder navigation.

From the main dike pronounced contrasts are to be seen. Trees are abundant in the inner, or older, areas but are scattered outside. In the polders house groups are smaller and more commonly of woven reeds rather than brick. There is no navigation on the canals outside the dike, and there are few old landmarks such as temples. In con-

trast to the planned rectangularity of the outer canal net, the older system is disorganized. No trace remains of original rivers, except possibly in the canals linking the larger rivers.

Two Thousand People to the Square Mile

People are inescapable in Fenghsien—old scholars giving their birds an airing, children tending the buffaloes, women weeding the crops, boatmen punting their shallow skiffs, groups of men and boys operating an irrigation pump. From dawn till dusk people are busy in the fields, and one can rarely find a secluded spot out of sight of humanity.

The average population density of the Yangtze Plain, which includes all the level land below Ichang, is 1277 to a square mile. In many parts of the delta this figure is doubled, as in the island of Tsungming in the Yangtze estuary, where there are 2873 people for each square mile. A recent estimate credits Fenghsien with a population of 304,480 and gives the area as 1238.5 square kilometers.[7] A census in 1865 reported 140,215 people. Across the canal from Chachiang a partial house-to-house census was taken of one square mile of farm land. This incomplete enumeration indicates a density of about 2050 to a square mile in a purely agricultural area. Individual house groups, sometimes of a clan, reported 2 to 30 families and 8 to 120 people. There are no resident foreigners in the area, and the only mission station is a Jesuit church and orphanage at Chingtsunchiang. The Southern Methodist Mission at Sunkiang has had several outstations in the county.

Except for the few urban centers, the population inside the main dike is evenly distributed. The surveys of the Whangpoo Conservancy Board locate practically all farmhouses and show no localization or systematic pattern of distribution. Canal junctions and trail intersections have not produced concentrated settlements. Roadside teahouses, isolated stores, and country temples are uncommon and have not resulted in settlement nucleuses. Almost without exception houses are on waterways, but the waterways are so closely spaced that there is no linear arrangement. Access to water is not needed so much for transportation as for domestic use.

There is little circulation on the part of the farm population. Each family group lives a practically self-contained life in the midst of the fields it cultivates. Only a few times a year is it necessary to visit the city for supplies or for temple festivals. There are few wants that call for frequent purchases at near-by shops, nor is there the ready money with which to satisfy such wants if they did exist. The few

[7] China Industrial Handbooks: Kiangsu, Bureau of Foreign Trade, Ministry of Industry, Shanghai, 1933. The area of agricultural land to a rural family is given as a little more than 26 mu—more than double the average for the province.

needs and the low rate of circulation probably account for the absence of focuses of rural settlement. In Fenghsien near neighbors are unavoidable, and there is no necessity to group farmhouses for sociability, as there would be in a more sparsely populated land.

Most buildings are made either of poorly burned gray brick, pounded earth, or woven reeds. There may be a veneer of plaster, usually whitewashed. The better buildings are roofed with tile; the others are thatched. The floor is made of brick or pounded earth. Farm buildings invariably are one-storied; only in parts of the larger towns are two-storied buildings to be seen. There are neither cellars nor attics. Windows, sometimes made of translucent sea shells, are few and small. Wood is expensive, and its use is restricted to doors, windows, and roof beams.

Every farmhouse has its courtyard for threshing grain and domestic uses. Unlike those of North China, these courtyards are unwalled except for a possible hedge. The houses have from two to ten rooms, arranged in a row, not more than three being connected. The usual arrangement is a combined kitchen and living room with a bedroom on each side. Simple chairs and tables, bedframes of woven fiber supported on stools, and chests for extra clothing make up the furniture. Instead of a barn, an extra room houses tools and supplies. The water buffaloes and yellow cows may have a shed to protect them from the rain, but pigs, chickens, and dogs find shelter for themselves. Each farm has a privy, where all human wastes are collected in large jars until needed on the fields. Threshing is done either with a flail or by driving the farm animals over the grain. In each courtyard are large piles of straw, to be used for fuel or perhaps for weaving cheap rope or making straw sandals.

The most elaborate structures are the temples, but most of the buildings are in need of repairs. Their roofs are made of uncolored tile. There is a nunnery at the north gate of the city of Fenghsien and another east of Kaochiao. The more pretentious grave plots may have an encircling wall and an ancestral hall for family tablets. Despite the antiquity of the area, there are surprisingly few material souvenirs of the past. There are no pagodas and only a few dilapidated pailous, or stone archways. Even the more important family graves are usually without stone markers. The stone bridges are probably among the oldest structures.

Farmers and Fishers

Three primary occupations furnish a livelihood to these people: agriculture, fishing, and salt production. The agricultural harvest consists of cotton and rice in the summer and wheat and broad beans in the winter. During the winter there is some fallow land, but in summer the whole countryside is under cultivation. Few fields

FIG. 4—The Whangpoo; similar nets are used on the canals.

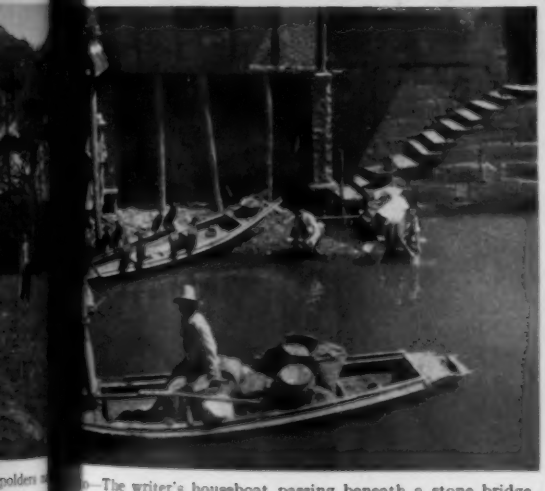
FIG. 5—Looking southwest along the main dike one mile south of Fenghsien city. The polder to the left is three feet higher than the land within the dike to the right.

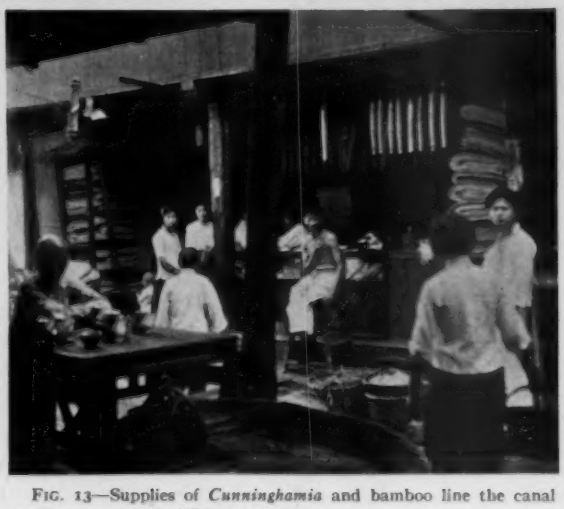
FIG. 6—Sweet potatoes on ridges with corn between every third row on left; rice field on right. The shelter covers a chain pump operated by a water buffalo.

FIG. 7—Brackish ground water in the outer polder a[rea] necessary to carry drinking water as much as a mile. [W]here single building.

FIG. 8—Wooden trays for evaporating salt brine along [the] sien foreshore. Piles of salt-impregnated silt at the left.

FIG. 9—Grave mounds dot the landscape. The more [im]portant graves are surrounded by trees.





o—The writer's houseboat passing beneath a stone bridge
enghsien canal.

11—The main west street of Fenghsien as seen from the

2—Canal scene at Chingtsunchiang, showing women washing
es, cormorants, and farm skiff.

FIG. 13—Supplies of *Cunninghamia* and bamboo line the canal at the western end of Chingtsunchiang.

FIG. 14—A farm house of the poorer class; corn field in foreground, grave mounds at right rear.

FIG. 15—Stores at Kaochiao open directly on the narrow street that here separates a tea shop from an umbrella and matting shop.

exceed 100 yards in length; many are only 100 feet long by 50 feet wide. A crop such as soybeans may be planted in two or three rows along a path, and much corn is grown in odd patches less than 10 feet in diameter. Where an entire area is in the same crop, it is often impossible to determine field boundaries. There are no fences and few stone corner markers. Muddy ridges a foot high and a foot wide separate flooded fields but are invisible amidst the standing crops. Maps of land utilization thus fail to show the tiny size of farm units, which through successive inheritance subdivisions have been reduced to small fractions of an acre.

Water buffaloes, yellow cows, and a few oxen are available for plowing, but a large amount of work must be done by hand. To ensure better drainage, sweet potatoes, beans, and, often, winter wheat are planted in ridges some ten inches high, which are spaded up by hand. Planting, weeding, and harvesting bring all members of the family into the fields.

Cotton has been raised around the sandy margins of the Yangtze delta for centuries. Today it is the dominant cash crop, and the development of modern mills in Shanghai has made the area the most important cotton-producing region in China. A small amount of cloth and braid is made in the homes, but most of the cotton is exported through hong merchants in the towns, where it is usually ginned before shipment. The cotton seeds are planted before the Ch'ing Ming festival in April, in the fields in which winter wheat has been raised, as soon as, or even before, the wheat is harvested. During dry summers the crop may be irrigated two or three times, but this is not always necessary. The harvest comes in late August and September. The staple is short and the yield low. Farmers report a yield of 70 to 100 chin (1 chin equals 1⅓ pounds) of unginned cotton to a mu (one-sixth of an acre). In many parts of Fenghsien cotton occupies two-thirds of the cropland, and almost everywhere it occupies half of it. On the sandy and saline soil of the polders it is more widespread than inside the main dike.

The yield of rice is inadequate to supply the local needs and must be supplemented by imports from Shanghai. It is reported to be from 100 to 180 chin of unhulled rice to a mu (18 to 32 bushels an acre). Rice requires more labor than any of the other staple crops. It is sown in seedbeds in April and transplanted in May to the fields in which broad beans have been grown during the winter. For three months the plants must be in standing water. Every rice field borders a canal or pond, and chain pumps are in operation every few days. About three-fourths of the pumps are worked by animal power. Along the main canals a few farmers have contracted for watering with a company that has an engine-operated pump, mounted on a boat so that it may be moved from field to field as needed.

Each farmstead has a small plot for vegetables and melons, carefully guarded by a watchman toward the harvest season. Corn, sweet potatoes, and soybeans locally cover as much as 10 per cent of the crop area each. A little kaoliang is raised for wine. Interplanting of corn and melons or sweet potatoes is common.

FIG. 16—Land utilization near Kaochiao, a small village one mile west of Fenghsien city (see Fig. 1). The map covers nearly half a square mile. The main canals lead north to Chachiang on the Whangpoo, west to Chingtsunchiang, and south to the main dike. Key: 1, grave mound; 2, temple; 3, building; 4, cotton; 5, beans; 6, rice; 7, sweet potatoes; 8, corn; 9, bamboo; 10, vegetables; 11, melons; 12, farmyards; 13, canal, with bridge; 14, path. Canals are mapped at water level. Their banks are 8 to 10 feet high and several feet wide, covered with reeds, so that there is actually less cultivated land than appears.

Wheat and broad beans are the winter staples. Wheat is planted in September, and broad beans are planted in October; both are harvested in April. They are reported to yield about 150 chin to a mu. Wheat, the more extensive crop, is shipped in part to Shanghai, and both wheat and rice straw is shipped to Shanghai for fuel.

Rotation is practiced rather generally, two years of cotton and wheat being followed by one of rice and beans. Some fields are kept almost continuously in cotton because of its cash return. In the newer polders, especially those that are saline, cotton covers as much as 80 per cent of the arable land. The rest of the area is in corn and soybeans but not rice. There is considerable winter fallow, along with some soybeans, but no wheat. No mulberry is grown, though silk is an important industry some tens of miles to the south and west.

About a quarter of the farmers are owners; the rest are tenants. Farm land is valued at $40.00 to $70.00 (Chinese currency) a mu.

The annual rent is $8.00 to $12.00 when paid in cash, but oftener it is a share of the crop. Taxes amount to $0.30 a mu every six months.

Fish largely replaces meat in the Fenghsien diet. There is some fishing in Hangchow Bay, but there are no harbors along the Fenghsien shore in which to land a catch. The fishing of Fenghsien is done in canals and ponds. Where there is a noticeable tidal movement, bamboo weirs with bottleneck enclosures have been built across the canals to trap the fish; elsewhere large, square nets, eight feet and more on a side, are let down from a bamboo framework. Trained cormorants also are commonly used, and fishermen usually have about a dozen of these birds to a boat. Most of the fishing is only a part-time occupation.

The ever industrious farmer harvests aquatic plants and bottom mud to fertilize the fields. With scythes attached to long poles he cuts the vegetation growing in the ponds and with a long-handled scoop shovel drags up the rich mud from the canal bottom.

Salt Production and Other Occupations

The production of salt from sea water along the Fenghsien foreshore dates back many centuries. The hsien records refer to salt boilers, but all the production today is by solar evaporation. Directly east of the city of Fenghsien dikes have been built out to the high-water mark, but farther south is a large unreclaimed area, which is covered with salterns. Twice monthly, on the first and the fifteenth of the Chinese month, this area is flooded at high tide. The tide leaves behind a veneer of salt-impregnated silt. As needed, the top quarter-inch of this silt is scraped from an area 100 feet or more in radius and is heaped into pyramids 10 feet high.

In front of each pyramid are two percolating basins. A few bushels of silt is placed in these basins, and water from near-by ponds or tidal thoroughfares is poured over them. This water dissolves the salt and slowly seeps into a cistern. Workers carry the brine from the cistern to wooden trays, into which it is poured half an inch deep and allowed to evaporate. Each day or two, as a layer of crystal salt accumulates, it is scraped up and is ready to be sold. The process continues throughout the year, but with lessened activity during the winter. Each tray is taxed eight coppers a year, and the salt is marketed under the supervision of the Salt Gabelle.[8]

Secondary production in Fenghsien is small. There are a few mills, engine operated, for hulling and polishing rice; cotton gins have already been mentioned; oilseeds are pressed into cakes in at least one factory; and there are blacksmiths, coffinmakers, tailors, and the like. On the banks of the Whangpoo at Chachiang are two establish-

[8] See J. E. Spencer: Salt in China, *Geogr. Rev.*, Vol. 25, 1935, pp. 353–366.

ments where coal dust from Shanghai is converted into coke for reshipment to that city. Other industry is confined to the home.

Trade and transport take the time of many, trade in the towns, transport over the canals. Most of the shops are small, open directly to the street, with a frontage of some twenty feet; but despite its

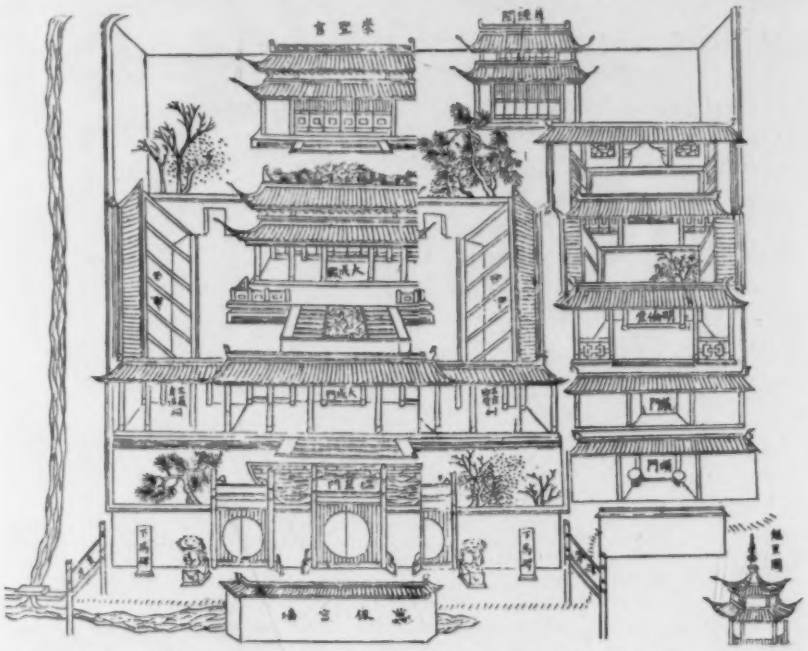


FIG. 17—Plan of the Confucian temple in Fenghsien city, reproduced from the *hsien* gazetteer. In the foreground is the spirit wall, behind which three circular gates lead to the first courtyard with its semicircular pool. The smaller buildings at the right are now used for a public library.

small size a shop may have a dozen apprentices. Regular boat service operates over the main canals. Company, or hong, boats, 30 feet long and sculled by three or four men, carry freight and passengers at low rates. Freight is mainly agricultural produce and moves by boats of various sizes. Where there is a towpath or when the wind or tide is adverse, trackers pull from the bank, but ordinarily boats are sculled by means of a large oar in the stern or are punted with bamboo poles.

The influence of Shanghai is increasingly felt. A steam-launch service from the Shanghai Bund, along the Whangpoo, operates three times a day, stopping at Chachiang. From Chachiang there is supplementary motorboat service once a day through the canals to Fenghsien city. Chachiang is reached from Shanghai in two hours and a quarter. Several dozen people a day make the trip, most of them small merchants or coolies looking for work in Shanghai. Most of the metropolitan contacts are indirect and reflect the increased market for cotton and the availability of imported rice.

An Old Walled City: Fenghsien

Two of the urban centers may be considered for their contrasts—the city of Fenghsien, the old, walled county seat, and Chingtsunchiang, a newer, unwalled commercial center along one of the main canals. These two towns are type examples for much of South China.

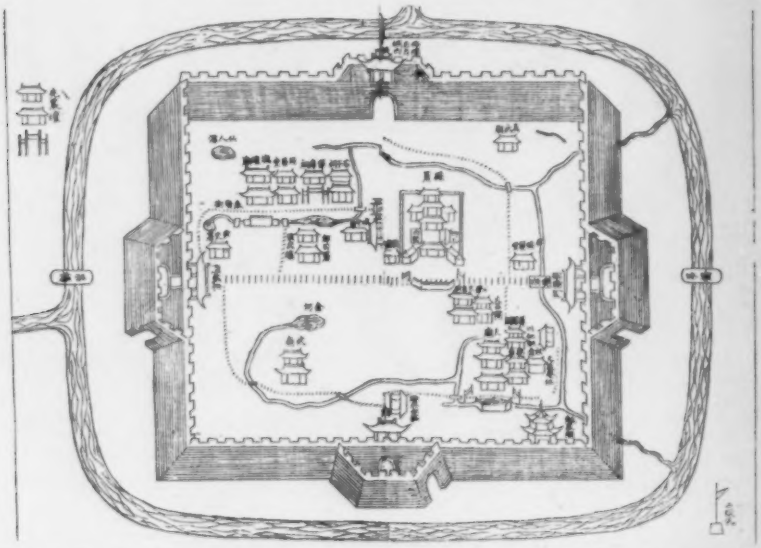


FIG. 18—The plan of Fenghsien city as given in the *hsien* gazetteer. The city wall is approximately 2300 feet square. The Confucian temple is at the lower right, the magistrate's yamen above it, and various temples to the left. The business district centers about the intersection of the two streets connecting the gates.

Fenghsien is laid out as a typical administrative center, in which capacity it served until recently when the county seat was transferred to Nanchiao. Encircling the city is the brick wall, originally built in 1386, nearly square, some twenty-five feet high and about 2300 feet long on each side, with a low parapet and bastions at short intervals. Outside the wall is a moat, originally 240 feet wide and 7 feet deep, but now about 75 feet wide. There are four gates, one at the middle of each side; each gate formerly had a gate tower and a screening extension wall, but the towers are now in ruins. Within the wall two principal streets connect the four gates, and their intersection locates the business focus. The present built-up part is a rough square, the corners of which touch the gates, so that a triangular area is left in each corner of the city; these areas are now devoted to agriculture. Even within this built-up part there are numerous ruins, which reflect the decadent political status of the town.

The streets are from 10 to 25 feet wide and have been paved with stone since 1832. There are no two-wheeled vehicles and few wheelbarrows. The shops are small and are limited to domestic needs.

The largest buildings are the former magistrate's headquarters or yamen, a large Confucianist hall, and several temples. As the hsien capital, Fenghsien was once provided with four granaries, which had a capacity of 110,000 catties (roughly 30,000 bushels). Near the Confucianist temple are a new-style school and a small reading room and public library. The city has one telephone but no electric lights.

FIG. 19—Urban land utilization in Chingtsungchiang (compare Fig. 2). Key: 1, retail business; 2, wholesale business, c = cotton, w = wood; 3, public use, i.e. school, temple, church; 4, urban residential; 5, rural residential; 6, canal, with bridge; 7, path. Scale: 1 inch to 350 yards.

Small suburbs cluster about each of the gates: the most important is that at the west, where the launch service starts for the Whangpoo.

A New City: Chingtsunchiang

Chingtsunchiang is 10 miles southwest of Fenghsien city on the main canal leading to Nanchiao, the present capital. It is the most important city of the region studied. The urban area extends 3700 feet along the canal and has a maximum width, including the canal, of 600 feet. The population in 1933 was 4533. These people, almost all of them living in one-story houses, occupy a built-up area of roughly one-tenth of a square mile. The main street follows the west bank of the canal, alongside it except in the central district, where shops are crowded in between. Across the canal is another, shorter street, of much less importance. Side streets are mere entryways from the countryside. Chingtsunchiang is unwalled, but the urban area is sharply defined. Fields extend directly to the almost continuous line of city buildings, usually without outward-facing buildings.

There is no pagoda, but there is a pawnshop with a fortresslike tower, from which one may view the pattern of the city. More than half of the area is under roofs. Residences and their tiny courtyards are directly connected with the family shop and seldom have a

separate entrance. No boundary can be drawn between business and residential areas; in fact, apprentices often sleep on benches in the shops. Except in the central district, one-story structures prevail.

Chingtsunchiang is a typical example of the teeming South China cities—tremendously congested, dirty, smelly, with innumerable diseased dogs, without conception of sanitation. Yet for all that there are signs of progress. Electricity, used in the larger shops only, is brought from Nanchiao. A new school has 300 children in six grades and kindergarten; the tuition is $6.00 (Chinese currency) a year. The former temple is now largely given over to a public tearoom and education hall, the only visible evidence of civic interest in recreation. Catholic influence is strong in this part of South China, and Chingtsunchiang has a Jesuit church and orphanage.

Four main lines of business distinguish the city: cotton, with three wholesale firms; wood, with two; beans, with one; and rice, with three shops. Cotton and beans go to Shanghai, from which the rice comes. The largest of the cotton firms has 90 small ginning machines, with a capacity of 32,000 pounds a day. The only weaving is done in the homes, where there are many small looms operated by women; their output is about 20 feet a day of a strip a little more than two feet wide. The trade in wood is extensive—poles from Foochow, bamboo from Hangchow, and other lumber from Hankow. The two firms, one at each end of the town, keep a considerable part of their stock afloat on the canal. An inventory disclosed a diversity of small enterprises: 44 were engaged in selling food and 21 in selling clothing; 39 in manufacturing and merchandising, including sale of new-style goods (flashlights, kerosene, cigarettes, soap, enameled washbasins, etc.); and 17 in services ranging from "spirit money" and native medicine to a native and a "foreign-style" hospital.

The Uniqueness of Fenghsien

The distinctive quality of Fenghsien lies in its intimate relation to water, the integrator of the landscape. Canals are the arteries of this composite organism. They provide circulation, nourishment, and elimination and determine the quality of the life that makes this land unique.

These artificial rivers carry off surplus rainfall and at the same time provide a rarely failing source of water for irrigation: thus they largely free Fenghsien from flood and drought. Few fields are more than 50 yards from either a rain-water pond or a canal. The canals are from 5 to 50 feet wide, and most of them are navigable for farm skiffs, though the smaller ones are partly obstructed by reeds. Their banks are from 8 to 12 feet high, according to the height of the land above sea level. Most transportation is by boat. Slower freight

boats move about two miles an hour; the faster sculled boats travel four to six miles an hour. A daily flow of vegetables and a seasonal tide of wheat or cotton move toward the cities, and out from them, in turn, comes the parade of gaily decorated "flower boats" carrying night soil to replenish the fields.

Many fine stone bridges cross the canals, some of them arched, others made from long, flat slabs of Soochow granite. They furnish excellent vantage points from which to observe the manifold functions of a canal. Near the edge of the typical village one may look countryward and see water buffaloes submerged to their nostrils for their daily soaking. Farther on, a fisherman paddles along in a boat while his cormorants dive for fish. Across the canal girls nearly as submerged as the buffaloes are gathering clams. Small boys float about in tubs collecting water chestnuts. A dozen geese swim silently along in search of food.

Toward the village, passing boats crowd the canal, here constricted by the accumulation of refuse; for in the absence of arrangements for the disposal of garbage or waste the canals form a convenient place to toss broken dishes and debris. Most villages have a common drain under the flagstones down the center of the street, and this too empties into the canal. Where the tidal range is adequate, the daily ebb and flow carries out refuse; elsewhere, especially during a protracted dry spell, the water becomes more or less stagnant.

Adjoining each house along the canal is a flight of stone steps, at the foot of which one may observe women doing the family laundry by pounding the clothes on a stone, or washing the daily rice and vegetables in a wicker basket sloshed in the water. To complete the picture, the canals are the sole source of water for domestic use, and water carriers at the foot of other steps dip up buckets of muddy water, which they peddle from house to house. Small wonder that the Chinese have learned to drink hot tea rather than unboiled water!

Without the protection of the maritime dikes this thronging life of the canals would not exist, but without industrious people there would be no dikes! It is thus man that is the most impressive element of the landscape.

AGRICULTURAL SOILS IN A LOESS REGION OF NORTH CHINA

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Oberlin Shansi Memorial Schools, Taiku

THE peculiar physical characteristics of loess and associated soil materials in North China have often been described, and their origin has been discussed at length. Comparatively little attention, however, has been paid to them as soils. In this paper results are given of a soils study in one of the provinces of North China where some of the best known of these deposits occur—the province of Shansi.[1]

Shansi is on the eastern border of that area commonly spoken of as Northwest China. The topography is predominantly mountainous. Mountains, most of them having a rocky surface, make up about 65 per cent of the total area. Tillable soil is found among them only as small patches of loess and red soil on and along the base of slopes or of alluvial deposits on valley floors. The highest peaks rise to about 10,000 feet above sea level, but most of the elevations do not exceed 6000 or 7000 feet.

Next in percentage of total area are the well known loess and red-soil basins and plateaus. Basins, of different sizes, may be found in many parts of the province; and much of the extreme west, along the Yellow River, is a plateau of the same topographic features. From a point of vantage these areas appear to be a succession of rounded, low-lying hills, not unlike large soil dunes. Closer inspection, however, reveals their real state of desiccation. Yawning gullies and deep ravines reduce the amount of tillable land by about half. In some places the gently rounded slopes are adaptable to cultivation; elsewhere, to prevent rapid erosion and to make tillage more convenient, terracing must be resorted to. A characteristic vertical cleavage in the upper soil layers, sharp-faced soil cliffs, soil pinnacles, and other curious shapes help to give these regions their distinctive appearance.[2] The area they occupy is between 20 and 25 per cent of the total area of the province.

Plains, although occupying only about 10 or 15 per cent, are agriculturally the most important topographic type. The principal plains lie in a belt, which stretches with only slight interruptions from the northeast to the southwest corner of the province. Typically they

[1] Indebtedness for laboratory work is acknowledged to the Bureau of Chemistry and Soils, U. S. Department of Agriculture, to the Department of Agronomy, Cornell University, and to the Department of Geology and Geography, Oberlin College.

[2] M. L. Fuller: Some Unusual Erosion Features in the Loess of China, *Geogr. Rev.*, Vol. 12, 1922, pp. 570–584.

G. B. Barbour: Recent Observations on the Loess of North China, *Geogr. Journ.*, Vol. 86, 1935, pp. 54–64.

are very level and are surrounded by abrupt mountain slopes. In width they range from 10 to 3 miles and in length from 20 to 100 miles. They are intensively cultivated and densely populated, supporting about 40 per cent of the population of the province. The elevation of the provincial capital, Taiyüan, on the central and most important plain, is 2500 feet above sea level. The southwestern plains are lower.

FIG. 1

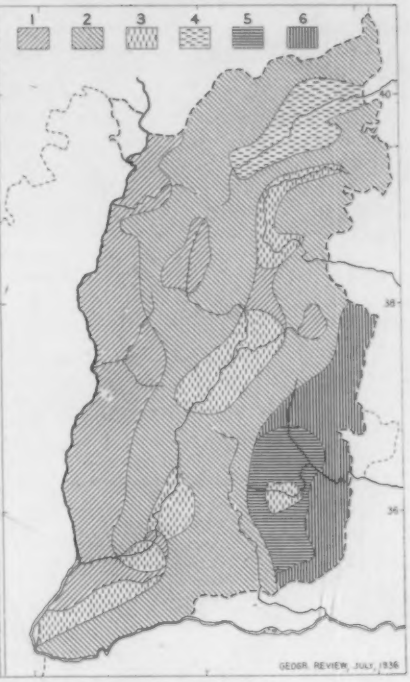


FIG. 2

FIG. 1—Location map of Shansi Province. Scale approximately 1 : 8,000,000.
FIG. 2—Soils map of Shansi Province. The subgroups represented are: 1, Calcareous Yellow-Gray soils; 2, Calcareous Yellow-Gray soils in mountain valleys; 3, Calcareous Gray-Brown soils; 4, Calcareous Gray soils; 5, Slightly Calcareous Red soils; 6, Slightly Calcareous Red soils in mountain valleys.

The winter northwest monsoon brings with it severely cold weather. Taiku, of about the same latitude, altitude, and precipitation as Dodge City, Kansas, has a mean temperature during the winter three months of 9° F. lower. As the winds shift during the spring and summer, to become a rather poorly developed southeast monsoon, day temperatures become high. Nights, because of the altitude, are usually cool. The average frost-free season on the Taiyüan plain is between April 15 and October 1.

Annual precipitation, in regions representing average conditions, is about 16 inches. Fortunately for crop growth, between 80 and 90

FIG. 3—Deep gullies and ravines, which reduce by about half the amount of land available for cultivation in those regions. The soil material exposed is mainly of the reddish earths.

per cent falls during the six months of the growing season. Spring rains are usually enough to germinate spring-sown seed, to mature winter wheat, and to carry other crops through their early stages of growth. Heavy rains fall during July and August. Rainfall, as in semiarid regions in general, tends to be erratic. Since the beginning of recorded history years of drought and attendant famine have periodically recurred.[3]

Moreover, wide differences in both temperature and precipitation occur in different parts of the province. Parts of Shansi are too cold for the production of winter wheat; in other parts cotton is admirably adapted. The Taiyüan plain receives an average rainfall of about 16 inches, but in the southeast corner of the province between 18 and 21 inches falls. In the north, and probably in the west as well, the average precipitation is only 13 or 14 inches.

Vegetation is of little importance as a factor in the development of most soils in Shansi, because it has not been allowed to remain on the soil and accumulate in the form of organic matter. For centuries weeds have been kept down on tilled soils, and crop remains have been gathered for fuel or eaten by sheep and goats. On other soils natural vegetation may still be found in some places—brush and wild grasses, though usually scanty, on the slopes; forest remnants, mainly pine and birch, in a few places, particularly under temple protection. But even here grazing of sheep and goats and the activities of fuel gatherers prevent the vegetation from exerting normal influence on the development of soil profiles.

The farmers of Shansi engage in animal husbandry and in the production of fruits, vegetables, and field crops. Chickens, hogs, sheep, and goats are widely raised, a small number to a household, living mainly on waste products and what they are able to pick up in and

[3] W. H. Mallory: China: Land of Famine, *Amer. Geogr. Soc. Special Publ. No. 6*, 1926; see pp. 38–42.

FIG. 4—Loess hills terraced to prevent erosion and to make tillage more convenient.

about the villages. Fruits and vegetables are also widely raised, in a few places as a specialized business but almost universally on a small scale for local consumption. The fruits include grapes, apples, pears, peaches, jujubes, persimmons, and apricots; the most common vegetables, Chinese cabbage, carrots, spinach, leeks, squash, cabbage, and eggplant.

The main business of the Shansi farmer, however, is the production of field crops (see Figs. 8 to 12). In the north and in the elevated regions of central Shansi oats, Irish potatoes, soybeans, and millet are most commonly grown; in the extreme southwest, winter wheat, cotton, and maize; in the rest of the province, winter wheat, millet, kaoliang (a sorghum), soybeans, and maize. Millet, furnishing both grain and fodder, is the most important crop. Extremely resistant to drought and, through its many varieties, apparently adaptable to all soils and temperatures, it is an admirable staple for this region.

The size of farms varies from region to region, ranging from a little more than 1 acre to about 14 acres. Where irrigation is possible or rainfall or topography favorable, the area is small; in mountainous or dry regions, where the yield to a unit of land is small, it is larger.

CLASSIFICATION OF SOILS

Classification of the soils of this region based on mature profiles is difficult because of the scarcity of such profiles. On slopes erosion by wind and water tends continually to remove the material of the upper soil horizons and to deposit it on the lowlands. Undisturbed soils are almost impossible to find. And the low precipitation makes the rate of profile development slow.

The best-developed profile found[4] showed a concentration of car-

[4] R. T. Moyer: Soils of Shansi Province, *Natl. Geol. Survey of China Soil Bull. No. 10*, 1935. pp. 15–16. In addition to tables of soil analyses this bulletin also includes tables of climatic data and a table showing percentage of crop area devoted to various crops and size of farms in representative areas of Shansi.

bonates in the B horizon, beginning about 9½ inches below the surface and extending as deep as 45 inches. Such a concentration is to be expected in semiarid soils. According to Marbut's scheme of classification,[5] these soils belong in the broad category of pedocals—soils that show in some horizon a concentration of carbonates greater than that in the parent material.

FIG. 5—Fossil profiles and different types of soil materials in the reddish earths, Chinchow.

Not enough profile development has been observed, however, to place the soils definitely within the great groups into which pedocals are divided. Mr. James Thorp,[6] chief soil technologist of the National Geological Survey of China, has found that in adjacent provinces similar soils are light chestnut earths, dark chestnut earths, and chernozems. All observations that have been made in Shansi indicate that its soils also are of these groups. Because rainfall over the greater part of the province is low, chestnut earths probably predominate; but it is likely that in the parts of greater rainfall soils are mainly to be classed as chernozems.

Distinct differences in characteristics exist, however, on account of difference in geological origin. Loess is by no means the only parent material of the soils of this region. The mass of earthy materials once described by the single term "loess" has proved, on later examination, to embrace at least four kinds of material differing from one another in characteristics and in origin. Three of these are important parent materials of Shansi soils. A fourth important type has arisen through shifting of the material by wind and water. Classed according to

[5] C. F. Marbut: A Scheme for Soil Classification. *Proc. and Papers 1st Internatl. Congr. of Soil Sci., Washington, D. C., June 13–22, 1927*. Washington, 1928, Vol. 4, pp. 1–31.

[6] James Thorp: Notes on the Relationships between the Soils of Shansi and Northwestern China, *in* Soils of Shansi Province, by R. T. Moyer (see footnote 4), pp. 40–42 (App. 3). See also the same: Geographic Distribution of the Important Soils of China, *Bull. Geol. Soc. of China*, Vol. 14, 1935, pp. 119–160.

origin, therefore, there are in this province not only eolian soils but also alluvial and lacustrine soils.

These differences in origin, together with accompanying differences in color, lime content, and texture, make natural, for description, a division into several subgroups. Four of these have been defined:

FIG. 6—The Taiyüan plain viewed from a bordering mountain.

the Calcareous Gray-Brown, the Calcareous Brownish-Gray, the Calcareous Yellow-Gray, and the Slightly Calcareous Red.

THE CHIEF PLAINS SOILS

The name "Calcareous Gray-Brown" is given to a group of soils that, in the surface horizon, are gray brown when dry, particularly after exposure to wind and sun, and that have been derived from alluvium or loess and alluvium. They are mainly a silt loam in texture, and they effervesce when treated with dilute hydrochloric acid. They have a hydrogen-ion value between 8.00 and 8.60, are low in organic matter, and are well supplied with essential nutrients, except nitrogen. Subsoils usually differ from surface soils only in being a little lighter in color. Where profile development has taken place, the B horizon is reddish brown and very slightly compacted. The soils are deep, and the underlying soil materials, consisting of loams, sands, and clays, extend in places to a known depth of at least 400 feet.

Alkali, mostly white alkali, reduces yield in some places and in other places is sufficiently concentrated to make crop growth impossible. Sand, which has been carried out of stream beds and deposited upon cultivated land by wind and water, also reduces the productivity of appreciable areas of land.

FIG. 7

FIG. 8

FIG. 9

FIG. 7—A fuel gatherer who is helping to keep low the growth of natural vegetation on mountains.

FIG. 8—Harvesting wheat grown on irrigated land, Taiku District.

FIG. 9—Pear trees growing on unirrigated land of the Yellow-Gray subgroup, Shouyang District.

The better soils of this subgroup, however, are immensely fertile. On irrigated experimental plots at Taiku a measured yield of wheat of 72.6 bushels an acre has been obtained. Farmers in the important wheat-raising area on the southwestern plains claim yields of 75 to 80 bushels an acre on the best irrigated land in good years. These figures are vouched for by resident missionaries. On unirrigated land during a good year we have harvested at Taiku 34.1 bushels of wheat, 38.9 bushels of millet, 47.3 bushels of kaoliang, and 22.5 bushels of soybeans to an acre. Whatever factors have made it possible, after 3000 or 4000 years of cropping, the soils of this region are still well supplied with essential nutrients and are very productive.

With the exception of the northern plain around Tatung, the soils of all the plains and of river-valley bottoms belong to this subgroup. Their distribution is shown on the map, Figure 2. Although the total area that they occupy is not so large as that occupied by

some of the other soils, their fertility combined with favorable topography makes them the most important subgroup in this province.

Tatung Plain Soils

The soils of the Calcareous Brownish-Gray Subgroup are brownish gray to medium gray or light gray in color, sandy loam to gravelly sandy loam in texture, and derived from soil material probably of lacustrine origin. The surface soils of this subgroup are usually less than three feet deep. Below them in some places lies a well consolidated calcareous hardpan, developed under ancient conditions of weathering; in other places the surface soils are underlain by clay loam, thin-bedded clay layers, fossiliferous sands, sand rich in lime concretions, or greenish-yellow clays.

Although these soils are reasonably well supplied with essential nutrients and are favored with a level topography, their sandy gravelly texture and a low and uncertain rainfall combine to reduce productivity.

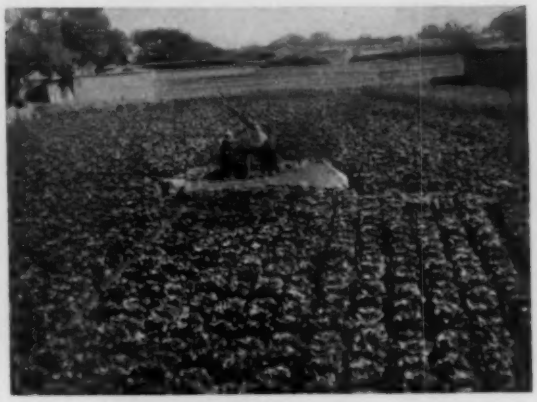


Fig. 10

Fig. 11

Fig. 12

Fig. 10—A field of Chinese cabbage at Chingyüan.
Fig. 11—A good crop of kaoliang.
Fig. 12—Millet is the single most important crop in Shansi.

FIG. 13—An area of the Taiyüan plain laid waste by sands blown out of a dry stream bed.

The main type of soil material from which these soils are derived occurs elsewhere in the province as a lower layer of the loess and red-soil hills, under layers of the yellow-gray loess and the reddish earths. It is considered to be of late Pliocene or very early Pleistocene age (lower Sanmenian).[7]

The occurrence of this subgroup as an important soil is limited to a single area, the Tatung plain.

SOILS OF THE NORTH AND CENTRAL BASINS AND THE WESTERN PLATEAU

In this subgroup are included soils that are yellow gray in color, of silty texture, and derived from true loess.[8] Profiles are immature or are lacking. All horizons are calcareous and have a hydrogen-ion value above 8.00. The soil is friable and in primary phase is uniform in texture throughout the profile; in secondary phase there may be strata or lenses of sand, loams, or sand and gravel. Its sharp vertical cleavages give it a typical columnar structure. Depth ranges from 10 to 150 feet.

These soils are well supplied with essential nutrients, except nitrogen. As is true of all other soils in the province, the organic matter is low. Although figures are lacking to show what this soil would produce were the moisture handicap eliminated, it undoubtedly is to be considered fertile. Sheet erosion—probably—reduces fertility in many localities; and because of a generally low rainfall productivity is usually not high.

[7] G. B. Barbour and M. N. Pien: The Pleistocene Volcanoes of the Sangkanho, *Bull. Geol. Soc. of China*, Vol. 9, 1930, pp. 361–370; P. Teilhard de Chardin and C. C. Young: Preliminary Observations on the Pre-Loessic and Post-Pontian Formations in Western Shansi and Northern Shensi, *Geol. Survey of China Geol. Memoirs*, Ser. A, No. 8, 1930.

[8] The term "Pleistocene" is commonly used to distinguish this material, yellow gray in color, from some of the underlying materials of a reddish color believed also to have been of eolian origin but of an earlier age. In this paper "true loess," "yellow-gray loess," and "Pleistocene loess" are used synonymously.

FIG. 14—The common fat-rumped sheep grazing on crop remains, Taiyüan plain.

Yellow-gray soils are found principally in basins of northern and central Shansi and on a plateau that stretches along most of its west border. In addition, they occur to a slight extent in mountainous regions throughout the province—occasionally in patches on slopes and along the base of slopes bordering broad river valleys. Although the yellow-gray soils predominate in these regions, soil materials of the Slightly Calcareous Red Subgroup outcrop in some places in sufficient amount to form an appreciable proportion of the total.

SOUTHEASTERN SOILS

Soils of the Slightly Calcareous Red Subgroup are pinkish or light red to brownish red in color, silty clay to clay in texture, comparatively low in lime content, and derived from the reddish earths. The lime content of samples analyzed is between 1.9 and 3.6 per cent, as compared with a range of 4.6 to 8.2 per cent for soils of the other subgroups. Their hydrogen-ion concentration is below 8.00.

There are no figures available to make a comparison of fertility. The supply of potash is high, but phosphorus is somewhat lower than in soils of other groups, and nitrogen and organic matter are low. The soils of this subgroup are generally considered to be less fertile than most other Shansi soils, but under a more favorable rainfall they are productive and support a dense population.

Considerable difference is to be found in their characteristics because of variation in parent materials. This variation is due in part to original differences in the parent material. In some places the loess thinly caps the reddish earths and enters into the composition of surface soils. In other places sandy and gravelly material outcrops and becomes the surface soil. Several well defined fossil profiles have been found in the reddish earths, and as erosion of the slopes proceeds any horizon of any of these profiles may become the

surface soil material. The predominating reddish color, it should be emphasized, is definitely a parent-material color and has not developed under present-day weathering. Geologically this material is regarded as being of early Pleistocene age and belonging to the upper-Sanmenian series.[9]

Soils of this subgroup occur mainly in the southeastern part of the province, where they form the principal soils of two basins and of the mountain valleys surrounding them. This region extends northward along the entire south half of the east border.

Improvements in Use of Soils

Extensive traveling over this area emphasizes the first impression that under present methods about all tillable land is being used to the limit of its capacity to produce. The smallest patches are assiduously cropped. Gullies are dammed to build up other patches upon which crops may be grown. Where slopes are steep, terracing is resorted to; and where particularly steep, stone retaining walls are erected. Where water for irrigation is available or the supply of natural precipitation sufficient, multiple cropping is practiced. Crop remains are grazed by sheep or goats. Timber is obtained from trees planted along irrigation ditches and roads and in villages. Little hope can be held for an appreciable expansion in the amount of tillable land or much improvement in the utilization of land now under cultivation.

Government figures on the amount of land cropped and calculations based on estimates of the percentage of each topographical type cropped agree in the conclusion that the tillable land probably does not exceed 20 per cent of the total area. However, certain improvements should make it possible to increase the productivity of land now tilled.

Adequate irrigation has been found on the average to about double yields. Increase in the amount of water available for irrigation will also reduce the hazard of famine. A considerable amount of land is now irrigated by water from both streams and wells. The greatest opportunity for future development in irrigation seems to be in the establishment of reservoirs. These should not only provide an increased and more regular supply of water but also reduce damage from flooding.

The importance of fertilizers is well understood, but the supply is inadequate. Whether or not this need can be met by the use of commercial fertilizers and which fertilizing elements are most lacking remain yet to be determined. Although the amount of nitrogen is low, crops are usually green; and additions of nitrogen-bearing fertilizers

[9] G. B. Barbour: The Taiki Deposits and the Problem of Pleistocene Climates. *Bull. Geol. Soc. of China*, Vol. 10, 1931, pp. 71–104.

may not be so important as the low total of nitrogen suggests. Anything that can be done to make more available the adequate stores of phosphorus and potash that these soils contain should be of benefit. In a plowing experiment now being conducted at Taiku, plowing to a depth of 7 inches instead of the usual 4 on an average of 5 years has increased the yield of wheat on unirrigated land 18.7 per cent. Although the experiment is not yet completed, several indications suggest that this increased yield is due to an increased availability of soil nutrients.

For the present the simplest and surest means of increasing yield seems to be the improvement of seed. Cropping without systematic selection through a long history has created a broad field of possibilities for the plant breeder. Results already obtained through the selection and isolation of pure lines from native varieties indicate that increases of 20 to 30 per cent are to be expected for most of the main crops.

A certain proportion of the bare mountain slopes might be made to produce timber. It is certain, however, that with the present rainfall forests will not grow successfully on many of these slopes until far more of a soil covering than now exists has been built up. Where present soil covering and precipitation are more favorable, immediate reforestation might be possible, and it should be worth while to begin experimentation for the purpose of determining where reforestation might profitably be undertaken.

THE LAKE HARBOUR REGION, BAFFIN ISLAND*

J. Dewey Soper

BAFFIN ISLAND, an area of 200,000 square miles, is one of the great islands of the world and the largest unit of the Canadian Arctic Archipelago. Although its exploration has been the object of numerous expeditions and individuals since Sir Martin Frobisher first sighted it in 1576, extensive parts of it are still imperfectly known. Such was the Lake Harbour region when the Canadian Department of the Interior detailed the writer to investigate it in 1930. The coast had been surveyed in broad outline but was inaccurately known in detail, and the interior had never been explored.

Geographical Work Accomplished

The plan of the work was similar to that undertaken by the writer on the expedition of 1928–1929 to Foxe Peninsula.[1] Lake Harbour, the station of a detachment of Royal Canadian Mounted Police, a trading post of the Hudson's Bay Company, and an Anglican mission, was chosen as headquarters. The writer arrived there by the Hudson's Bay Company's *Nascopie* on July 30, 1930. A residence and a warehouse were constructed with the assistance of the Eskimos during the remainder of the summer and fall, and a survey was made of the coast from Lake Harbour to Beaulieu Bay, White Strait. An astronomical position was established 27 feet southeast of the warehouse in longitude 69° 54′ 45″ W., latitude 62° 50′ 36″ N. From this was built up a system of triangulation designed primarily for main mapping control on a multitude of points on the coast, both north and south of the harbor. The plan involved the employment of nine stations, six of which were on major elevations (229, 348, 400, 450, 663, and 693 feet) throughout the locality and were marked by stone beacons.

After the residence was built in the fall, the main instrument station was transferred to a more convenient position for daily observations, and a new reference post was established in the astronomical meridian. This point will assume its greatest importance in the future as a repeat station for the purpose of determining the change in magnetic declination with the passage of time. During 1930–1931 the writer took 155 hourly readings at this station, the average of all the declination values being N 49° 50′.2 W. The means of readings (reduced to International Standard) on the Soper River are as follows:

*Published by permission of Lands, Northwest Territories and Yukon Branch, Department of the Interior, Ottawa, Canada.

[1] See J. D. Soper: Explorations in Foxe Peninsula and along the West Coast of Baffin Island, *Geogr. Rev.*, Vol. 20, 1930, pp. 397–424.

SOPER RIVER
LAKE HARBOUR DISTRICT
BY J. DEWEY SOPER
1931
SCALE 1:470,000
6 MILES
6 KILOMETERS
Cascades and rapids
Triangulation stations
Heights in feet
Rolling plateau region 1400 - 1600 feet above sea level
Livingstone R.
Willow R.
Joy R.
Soper R.
Joy Mt.
Moore Mt.
Fleming Hill
Lake Harbour
Falls
Cascade R.
Pleasant Inlet
Lake Harbour
Itinerpuk crossing
Copeland I.
Tersch Pt.
McKellar Bay
North Bay
Napakti I.
Cape Wight
Pudlatin Is.
Wishart I.
Mt. Chaunsler
Lavoie
Lee I.
Forder I.
Beacon I.
Itivirk Bay
Cape Tanfield (Ty Cape)
White Strait
Big Island
High Bluff I.
Numerous small islands comprising the Upper Savage Is. of which High Bluff is the largest
Juet I.
Carew Bay
Philpot Bay
Manitok Cape
Michael Point
Fenton Is.
Ayde Point
Hudson Strait
Rugged terrain with elevations 600 - 1000 feet above sea level
Powerful rapids and cascades
Falls
Current 5-6 m.p.h.
Current 4-5 m.p.h.
Current 6-7 m.p.h.
Current 8-10 m.p.h.
Current 2-3 m.p.h.
Sandbank or bench 20'
Sandbanks 40'-50'
Sandbanks 12'-15'
Sandbank 8'-10'
Immense deposits of sand and gravel along the river
According to Eskimo report the Soper R. has a great length to its source, so also the Joy, Willow and Livingstone Rivers
River takes a tortuous course, valley deeps with an average width of about one half mile. Sand and gravel benches up to heights of 180 ft. above the river
Mountains principally granite with some gneiss, schist, trap rock and crystalline limestone
1500' (approx.) Prominent peak triangulated from Lake Harbour
Average width 250' - 290'
600' - 1000'
LAT. 62° 50' 40" N. LONG. 69° 58' 45" W.
LAT. 62° 57' 58" N.
LAT. 63° 05' 19" N.
LAT. 63° 01' 56" N.
LAT. 62° 34' 28" N.
Baffin Bay
BAFFIN ISLAND
Foxe Basin
Davis Strait
Hudson Strait
0 50 100 150 MILES

FIG. 1

FIG. 2—Winter view of a part of the Lake Harbour settlement, looking south. April, 1931.

latitude 62° 58′—N 50° 23′ W; latitude 63° 06′ 30″—N 52° 52′ W; latitude 63° 11′—N 53° 16′ W.

During the winter a considerable amount of exploratory work was done in new territory by means of sledge and dog team. Many minor details were also filled in along the coasts of North Bay and westward. A detailed survey was made of the shore line of Soper Lake[2] and was extended to include a traverse of the Soper River beyond Fleming Hill to latitude 62° 57′ 30″ N. The final piece of work at this time was a transit, steel-tape, and stadia survey of the entire Lake Harbour settlement.

The following spring and summer the Soper River was surveyed by canoe to latitude 63° 16′ N. and the coast southeast of Lake Harbour to Ayde Point, in latitude 62° 31′ N. This completed the geographical work accomplished during the season of 1931. On August 1 the writer boarded the *Ungava* at Lake Harbour for Churchill, Manitoba, the terminal of the Hudson Bay Railway, en route to Ottawa, which was reached on August 18.

SOUTHEASTERN BAFFIN ISLAND

In southeastern Baffin Island the land is especially high in the more central parts—1000 to 3000 feet above sea level—from near Gabriel Strait to a point southeast of Amadjuak Lake. This higher terrain, as represented by the outer range next to the Hudson Strait shore, terminates at Fair Ness and Markham Bay.[3] Westward the land gradually lowers to a minimum elevation between Chorkbak Inlet and Andrew Gordon Bay. The mountains far inland to the northeast of Markham Bay are probably the highest in the peninsula area between Frobisher Bay and Hudson Strait.

[2] The Soper River and Soper Lake were so named by the Geographic Board of Canada in honor of Mr. Soper's explorations. The Soper River is known to the Eskimos of Lake Harbour as the Koukdjuak and was referred to by Mr. Soper on his field map as the South Koukdjuak. To avoid confusion with the larger and better-known Koukdjuak River that drains Nettilling Lake to Foxe Basin, the new name was given in accordance with the Board's usual policy.—EDIT. NOTE.

[3] Robert Bell: Report of an Exploration on the Northern Side of Hudson Strait, *Canada Geol. Survey Ann. Rept.*, Vol. 11 (N.S.), 1898, Ottawa, 1901, Part M, p. 13.

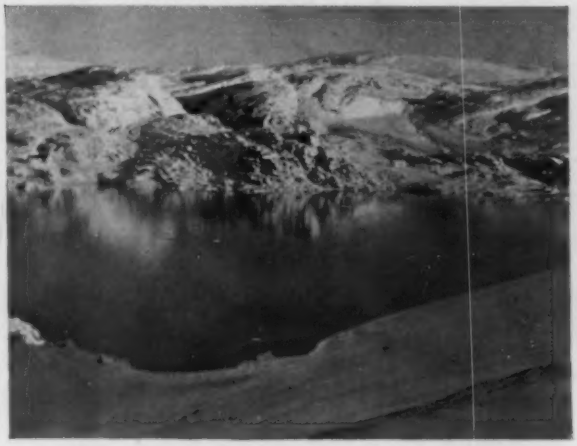


FIG. 3—Coastal scene at Lake Harbour in early November.

One of the striking features of this peninsula is the Grinnell Glacier, in the mountain tract bordering the south shore of Frobisher Bay. It is said to be about 80 miles in length by 20 in breadth. Its east end is at no great distance from Gabriel Strait. It discharges into Frobisher Bay at one or more places, and the Eskimos say that many of the small bergs observed in the southeastern waters had their origin there. Bell was told that a narrow stream of ice from the height of land on the south border of the Grinnell Glacier finds its way directly to Hudson Strait, but apparently no one has so far been able to verify this. The Grinnell Glacier doubtless exerts a refrigerating influence on the summer climate of the district. The Eskimos say that caribou commonly resort there to escape the ravages of mosquitoes during the warmer season. The smooth, undulating summit of the glacier, at an elevation between 2500 and 3000 feet, is distinctly visible in clear weather from vessels passing well out in Hudson Strait.

One of the notable physical features of the south coast is the amazing profusion of islands. Northwest of Big Island the shore is fringed with innumerable rocky islands; in some areas they are thickly clustered together and form a bewildering maze. This belt, or archipelago, is most pronounced between Fair Ness and Chorkbak Inlet, where it extends 10 to 25 miles from the coast; the widest part is in the vicinity of Amadjuak Bay. Beyond Chorkbak Inlet and between North Bay and the Middle Savage Islands the islands are much less numerous. They range in size from islands many miles in length to mere rocks, which are interspersed with dangerous shoals. As a rule the largest, boldest, and highest islands lie toward the mainland, while the outermost ones are smaller and lower.

The largest and most conspicuous island of the coast is Big Island, triangular in shape, with sides 35 miles, 25 miles, and 25 miles long. On the White Strait side it is particularly bold, many bluff headlands and steep slopes rising magnificently from the sea to an undulating plateau at an apparent elevation of 800 to 1000 feet; on the higher areas snowbanks persist until late in the summer.

Lake Harbour

Lake Harbour is the best and most important harbor in the region. At its head is one of the three white settlements on the south coast of Baffin Island. The harbor proper is exceptionally well sheltered and is 11 miles inland from the open sea of North Bay. The approach for ships, east of the Upper Savage Islands, is toward Beacon Island on a bearing of 50° true from the east end of High Bluff Island. Beacon Island (surmounted by a wooden beacon about 30 feet high, shaped like a truncated pyramid) is near the entrance to Lake Harbour and 11.8 miles in an air line to the southeast of the settlement. The narrowest part of the harbor, opposite the coaling depot, is about 280 yards wide, but the water is deep and ample for any of the ships that now navigate the northern seas. The maximum rise and fall of tide is about 30 feet.

Most of the land in the neighborhood of Lake Harbour and much of the coastal fringe to the south, east, and west range in height from 50 to 700 feet. Ten to twelve miles north of the harbor the well defined south wall of the inland mountain range rises roughly parallel to the coast to elevations of 1200 to 1500 feet. Beyond there is a gradual increase in elevation. The terrain is exceedingly rugged throughout the coastal zone, whereas the mountain plateau is more generally rounded and rolling.

The general contour indicates that the region has been heavily swept by ice, though not so recently as some other parts of Baffin Island—about Cumberland Sound and Nettilling Lake, for instance, where the striae and sheen of ice polishing are surprisingly fresh. Signs of more recent glaciation appear on the mountain range north of Lake Harbour, in contrast with the coastal area, which has undoubtedly been subjected to a much longer period of atmospherical erosion since the withdrawal of the land ice. The general astronomical direction of the striae between Cape Tanfield and Amadjuak Bay is about S 34° W; farther west, particularly beyond Chorkbak Inlet, it is more nearly true north-south.

The rocks of the Lake Harbour country are chiefly granites, gneisses, and schists. The most outstanding and interesting geological feature, however, is the crystalline limestone, to which attention was first drawn by Bell. The headland, Kingmaru, at the extremity of Lake Harbour, is composed entirely of this rock. It is an impure crystalline limestone, containing grains and crystals of siliceous minerals, which weathers to form considerable amounts of sand. This limestone outcrops at intervals for miles about Lake Harbour and was traced along the valley of the Soper River to latitude 63° 08′ N. Owing to the almost complete absence of soil and vegetation, the whitish color of the limestone on the sides and tops of hills and ridges makes them very conspicuous in the landscape; from a considerable distance

the bands might easily be mistaken for slightly discolored glaciers or old snowbanks.

The region appears to be relatively unimportant as regards economic minerals. Little systematic prospecting, however, has been done. Mica was mined for at Lake Harbour as early as about 1900, one of the old mines being near the northeast shore of Soper Lake. These pits were abandoned, but the Hudson's Bay Company now derives mica from deposits northeast of Lake Harbour, the work of mining and transporting the mica being done entirely by the Eskimos. The mineral is ground locally before shipment.

Marine terraces in this part of Baffin Island are not so numerous, fresh, or conspicuous as on the Foxe Peninsula. Here the land seems to have been emerging relatively rapidly during the geologically recent past. Many terraces were observed by the writer, however, between White Strait and Philpot Bay (latitude 62° 31′ N.) up to at least 300 feet. The highest terrace seen by Bell on the north side of Hudson Strait was 528 feet above present sea level.

The coast between Pleasant Inlet and Crooks Inlet, although very ragged and furnished with several good harbors, is not characterized by deep bays and inlets. For much of the length of White Strait it is screened by low-lying rocky islands, which a voyager offshore may easily mistake for the mainland; this condition is common along the coast of many parts of Baffin Island. The land adjacent to White Strait is rough and rocky, about 50 to 500 or 600 feet in elevation, and it inclines gradually northward. Most of the surface is destitute of vegetation and is very desolate, especially on the small, exposed islands.

The Interior

In the valleys of the mainland an impoverished carpet of lowly plant life covers the ground and imparts some touch of life and softness to the surroundings. Farther inland, in sheltered nooks and dales and especially bordering rivulets and streams, the vegetation is markedly more luxuriant. Grasses and dwarf willows are frequently knee-high in restricted areas, and a wealth of bearberry, crowberry, white heather, and other shrubs and flowering plants decks the rocky valleys and the lower slopes of southern exposure.

Almost without exception the water of Baffin Island streams is pure and beautifully transparent and the flow fairly constant and regular throughout the summer. The myriad rivulets are probably derived from the gradual summer thawing of the ground on hill slopes and mountain sides. Most of the rivers are characterized by rapids, cascades, and falls. The larger ones range in length from about 40 miles to 60 miles or more; their sources are at or near the height of land.

Small, clear lakes abound in the mountains and hills in the pre-

FIG. 4—Eastern slope of the Soper River valley in about latitude 63° 04′ N. Extensive alluvial deposit of sand and gravel in the foreground.

Cambrian areas of the island. Most of these lakes are girt with massive rock and sandy shingle, but many of the smaller ones are bordered by mossy and grassy shores. No conspicuously large bodies of fresh water are known in the peninsula area between Frobisher Bay and Hudson Strait, but to the north are the two large, well known lakes—Nettilling and Amadjuak. Another lake, which no white man has ever seen, lies north of Nettilling Lake and is drained by the Hantzsch River; and there appears to be yet another of considerable size between Frobisher Bay and Amadjuak Lake, probably drained by the Sylvia Grinnell River. Bell heard of this lake in 1897. He wrote: "Various reports reached me of a large lake lying not far from the head of Frobisher Bay, but these may refer to Lake Amadjuak, which extends in that direction." The original reports are doubtless correct; for on the

FIG. 5—Valley of the Soper River in the neighborhood of the Willow River. Mt. Moore in right distance.

FIG. 6—The heavily glaciated character of the terrain as seen at an elevation of 1560 feet, overlooking the ravine of the Soper River in latitude 63° 10′ N. July 1, 1931.

present expedition independent native reports to the writer told of a large lake northwest of Frobisher Bay, clearly unconnected with Amadjuak Lake. As a rule Eskimos are most dependable in their statements regarding physical features, wild life, and natural phenomena. There, therefore, appear to be four large lakes in the southern Baffin Island interior instead of the two now shown on some maps. Some maps show three large lakes, but the statement that one lies between Nettilling and Amadjuak lakes was proved to be erroneous by the explorations of L. T. Burwash and the writer.[4]

[4] A. E. Millward, edit.: Southern Baffin Island: An Account of Exploration, Investigation and Settlement during the Past Fifty Years. North West Territories and Yukon Branch, Dept. of the Interior, Ottawa, 1930, pp. 50–62 (The Work of Burwash in the Interior and Southwest, 1923–24) and 67–83 (The Explorations of J. D. Soper, 1924–26).

FIG. 7—Valley of the Soper River in vicinity of the Willow River, looking north from elevation of 1500 feet.

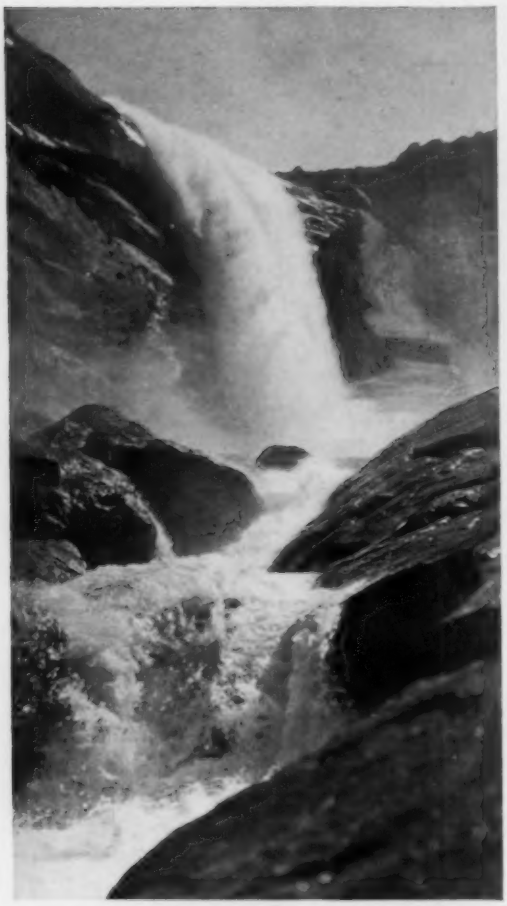


FIG. 8—This 95-foot waterfall on the Cascade River, tributary to the Soper, is the highest known fall of comparable volume in southern Baffin Island.

THE SOPER RIVER

The exploration of the Soper River by the writer in late June and early July, 1931, provided a cross-section view of the mountainous interior north of Lake Harbour. This river is the largest in southern Baffin Island known to discharge into Hudson Strait. Near the mouth is a series of rapids three-tenths of a mile long, with a fall of 20 feet. Above is a lakelike expansion, and for several miles the stream meanders with a sluggish current. North of latitude 62° 58′ the current is swifter, and beyond latitude 63° 04′ rapids occur with increasing frequency. This part of the gap cut by the stream is more than ordinarily impressive. The average width of the valley is between one-half and three-quarters of a mile, and the ramparts on each side rise everywhere from 1000 to 1500 feet (see Fig. 1).

As the valley is ascended the luxuriance of the vegetation, especially of the willows, increases noticeably. At the sea the willows are prostrate or rise only to a foot or two, while here bushy clumps from three to four feet high were frequently seen. Farther up the valley, on the banks of the Willow River, they reach the greatest observed height of more than 12 feet.

North of 63° 06′ N. the Soper has four principal tributaries south of Mt. Joy, all rapid and unnavigable: on the west, the Livingstone, Willow, and Joy rivers; on the east, the Cascade River, particularly wild and tumultuous, with a descent of about 560 feet in 3.5 miles, including a magnificent fall with a sheer drop of 95 feet.

On both sides of the Soper River, in the neighborhood of Fleming Hill and a few miles to the north, are low, marshy flats dotted with

numerous shallow ponds—typical tundra, supporting flocks of breeding Canada geese. This feature almost disappears in the tortuous course of the stream farther north. In its place are immense alluvial deposits of sand and gravel, forming flat-topped benches on both banks of the river from latitude 62° 58′ as far as the survey was carried. The greatest development of the benches is between latitude 63° 03′ and the vicinity of the Willow River. Those bordering the stream are from 10 to 20 feet up to about 50 feet in height; the higher benches ascend terracelike up to at least 110 feet above the stream. In the vicinity of the Livingstone River are two well defined benches at elevations of 80 and 110 feet.

FIG. 9—Cataracts on the northeastern shore of Philpot Bay; height about 250 feet.

During the course of the survey the mountain range was ascended with aneroid barometer in two places: in latitude 63° 03′ on the west side of the Soper, where an elevation of 1470 feet was recorded; and a little south of the Willow River a mile west of the main stream, where the reading was 1560 feet. On the south-facing slope of the valley in the second locality relatively rich vegetation was seen up to about 1000 feet but was most notable up to 800 feet, where willow shrubs 2½ feet high were seen bordering a small brook. Beyond the 1000-foot level the glaciated rocks were mostly barren. From the top of this mountain a remarkable view was presented. The surface exhibits the deeply undulating and rounded ridges characteristic of ice-ridden country. Along the course of the river most of the surface is rugged, with deeply eroded tributary valleys, bold promontories, and mountain peaks, upon the higher of which snowbanks persist until late in the summer, and in some places probably from season to season. The

valley walls show many magnificent cliffs, with enormous talus slides at their base. Much farther to the north the plateau could be seen gradually rising to elevations of at least 2000 feet. Police and trading parties who have crossed the peninsula by sledge report heights between 2700 and 2800 feet. Doubtless maximum elevations on both sides of the trail exceed this by several hundred feet.

The Eskimos state that there is a good sledge route up the Livingstone River for a distance, thence overland through the mountain valleys to Crooks Inlet and Markham Bay. In fact, it is asserted that, once the plateau is reached anywhere by means of the grades afforded in streams and ravines tributary to the Soper, sledge travel is tolerably easy and rapid.

Beyond Mt. Joy the river rises even more rapidly; it has less volume of water but an increasing number of rapids and cascades. The temperatures are lower on the top of the plateau, with a consistently severer climate, than at the seacoast; the summer is probably no longer than six or seven weeks. As far as could be ascertained from the natives, the Soper River rises in many small confluent streams about 60 or 70 miles north of Lake Harbour. Here in the hill basins are said to be numerous small lakes bordered by swamps of grass and tussocks that are resorted to by nesting red phalaropes, Lapland longspurs, and other birds.

Use of the canoe is feasible only as far as Mt. Joy, or for a distance of about 35 miles by river from Lake Harbour. From Mt. Joy to the sea the Soper River falls about 184 feet, or an average of about six feet to the mile.

The Coast Southeast of Lake Harbour

One of the natural attractions of the coast southeast of Lake Harbour is Glasgow Falls, at the head of Glasgow Inlet, where the 25-yard-wide river plunges down an almost vertical incline about 30 feet high directly into the sea. During the early summer the volume of water in the falls is so great that under favorable conditions its roar may be heard at the settlement, 5½ miles distant. There is said to be an even larger cataract upstream. On winter hunts for caribou the Eskimos sometimes follow the river as a route to the interior.

The coast southeast of Lake Harbour is indented by many large bays and inlets. One of the largest of these is McKellar Bay, nine miles long. The encompassing hills, up to 600 or 700 feet high, are bold and largely barren of plant life. At the head of the bay a strong river enters, coming in a half-mile series of wild cascades from a lake above. By way of this river a time-honored Eskimo sledge route leads to the height of land and northeast to Frobisher Bay. At the southeast entrance is a cluster of islands, large and small, with many bewildering passages, through which the changing tides rush with sinister currents

and eddies. It is a favorite sealing locality for the Eskimos, especially during the winter, since the *shukbuks*, or open tide rips, persist in the icy channels throughout this season.

Itivirk Bay, immediately to the south, has a length of seven miles. A prominent landmark about a mile northeast of the northern extremity is Mt. Chaunsler—a great mass of gray and reddish gneiss

FIG. 10—Looking south from the north end of Philpot Bay at low tide.

about 1000 feet high. Beyond it the coastal range rises gradually toward the interior to much greater heights. The shores are either precipitous—where no convenient landing can be effected—or littered with stones and boulders. At the head of many of the bays muddy tidal flats appear at low-water levels. Four miles southeast of Cape Tanfield is the large Juet Island, separated from the mainland by a narrow passage. Near the north end is a high, barren hill some 700 or 800 feet high. Here a succession of small islands fringe the coast and furnish a more or less sheltered inside passage for small boats. Outside, the sea is clear and deep, but there are at least two reefs at a distance of about a mile from shore.

North of Manitok Cape stretches the long Carew Bay. Two miles from the entrance is a narrows of only about 350 yards, through which the rising and falling tides pour a swift current. During the winter, with open sea against the coast between Manitok and Tanfield capes, the Eskimos travel up Carew Bay and overland to Itivirk Bay on their journeys to and from Lake Harbour.

Explorations of the present expedition terminated at Ayde Point in latitude 62° 31′ N., at the southeast entrance to Philpot Bay. The bay is nine miles long, and its average width is about one mile. It exhibits some of the most striking scenery on the south coast of the island. Naked rocks rise to elevations of more than 1000 feet. Still farther to the north and northeast the land rises at least another thousand feet to form the backbone of the range south of Frobisher Bay, which is crowned, in part, by Grinnell Glacier. The terminal third of the bay is particularly picturesque.

A multiple cataract of great natural beauty occupies a prominent position on the east side, three miles from the head of the bay; the cataracts leap over a ledge about 250 feet high and, cascading down the face of the cliff, plunge directly into the sea. An impetuous river of considerable volume, exhibiting a virtually continuous succession of rapids and cascades, enters the head of the bay through a deep, narrow defile in the hills. The Eskimos state that the river has its source near the height of land to the north-northeast. A mile to the southeast another boisterous stream enters the bay from the east by way of a series of small lakes. This stream is a favorite of the Arctic char, which ascend it to the lakes above in large numbers during the July run. Signs of old summer camps abound in the vicinity; for it has been a fishing resort of the Eskimos for an indefinite period.

REGIONAL PLANNING IN THE JACKSON HOLE COUNTRY

Preston E. James
University of Michigan

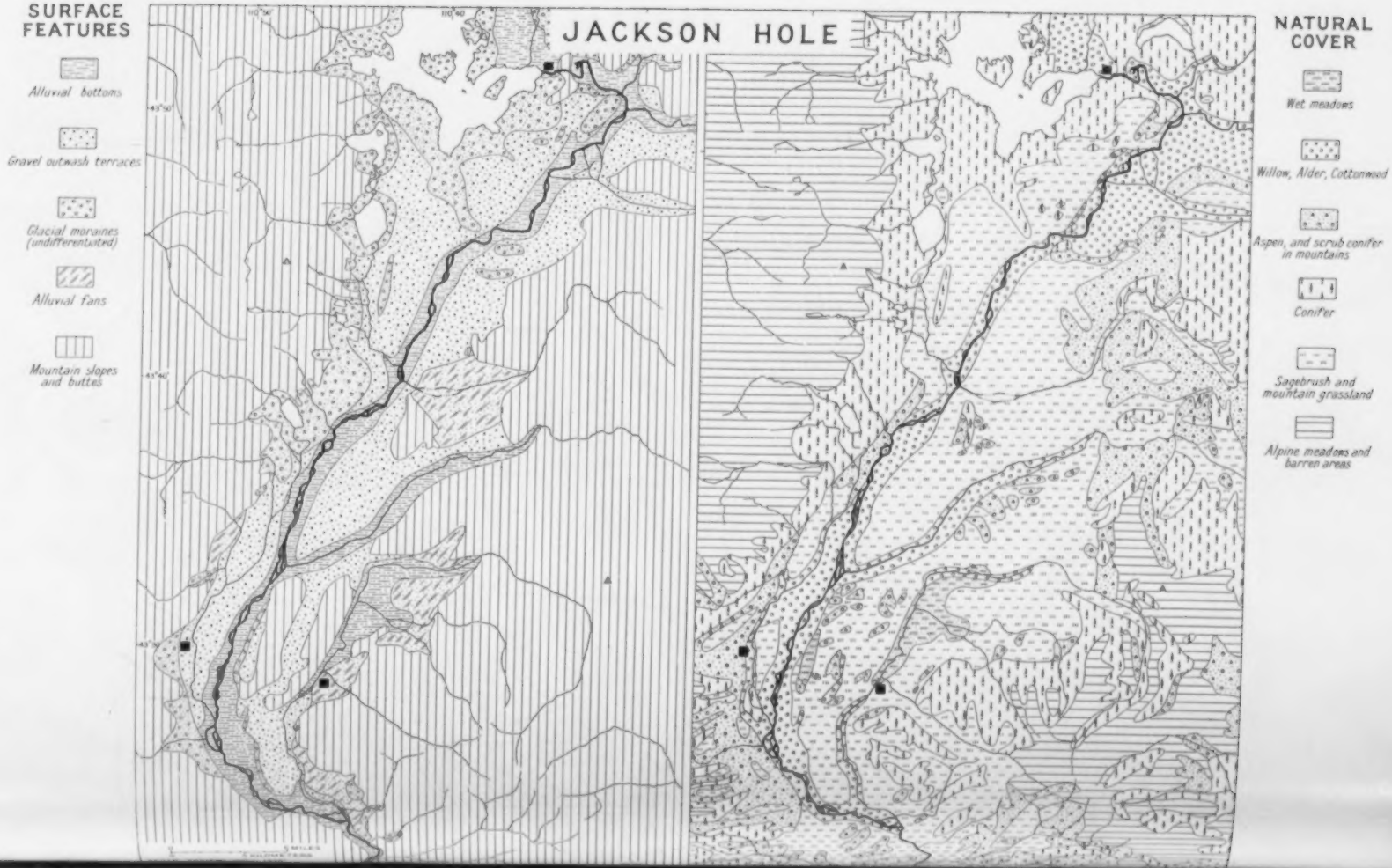
FIG. 1—Location map of the Jackson Hole region. Scale 1 : 2,000,000.

Too many regional plans and too many regional planners have succeeded only in stalling the process of settlement in the Jackson Hole country of western Wyoming. This situation is the result of the impact of two opposed projects: one that looks toward the progress of settlement and the shift from cattle ranching to more intensive forms of economy; and another that calls for the removal of the settlement already established, the return of the area to its natural state, and the maintenance in it of herds of wild game. Thus there has been created an economic and political situation for which a compromise is difficult to discover.

THE LAND

The territory involved in these matters is an intermontane basin, some 40 miles long by 8 miles wide, lying at an elevation of 6000 to 7000 feet in the midst of the Rocky Mountains of western Wyoming, just to the south of Yellowstone National Park. On its west side Jackson Hole is overshadowed by the abrupt and imposing front of the Teton Range, a block of ancient crystalline rocks tipped toward the west. The sharp pinnacles of crumbling rock, excavated on the upstanding edge of this block by the valley glaciers of the Pleistocene, reach elevations of more than 13,000 feet. Towering 7000 feet above the floor of the basin, they provide some of the finest alpine scenery of the western United States. Some small glaciers still exist on the east side of the range.[1] The east side of Jackson Hole, on the other hand, is bordered by the Gros Ventre Mountains, which rise more gradually through a wide zone of foothills to summits between 10,000 and 12,000 feet above sea level, but placed well to the east and south.

[1] Fritiof Fryxell: Glaciers of the Grand Teton National Park of Wyoming, *Journ. of Geol.*, Vol. 43, 1935, pp. 381–397.


JACKSON HOLE
SURFACE FEATURES
Alluvial bottoms
Gravel outwash terraces
Glacial moraines (undifferentiated)
Alluvial fans
Mountain slopes and buttes
NATURAL COVER
Wet meadows
Willow, Alder, Cottonwood
Aspen, and scrub conifer in mountains
Conifer
Sagebrush and mountain grassland
Alpine meadows and barren areas
110°40'
45°50'
45°40'
45°30'

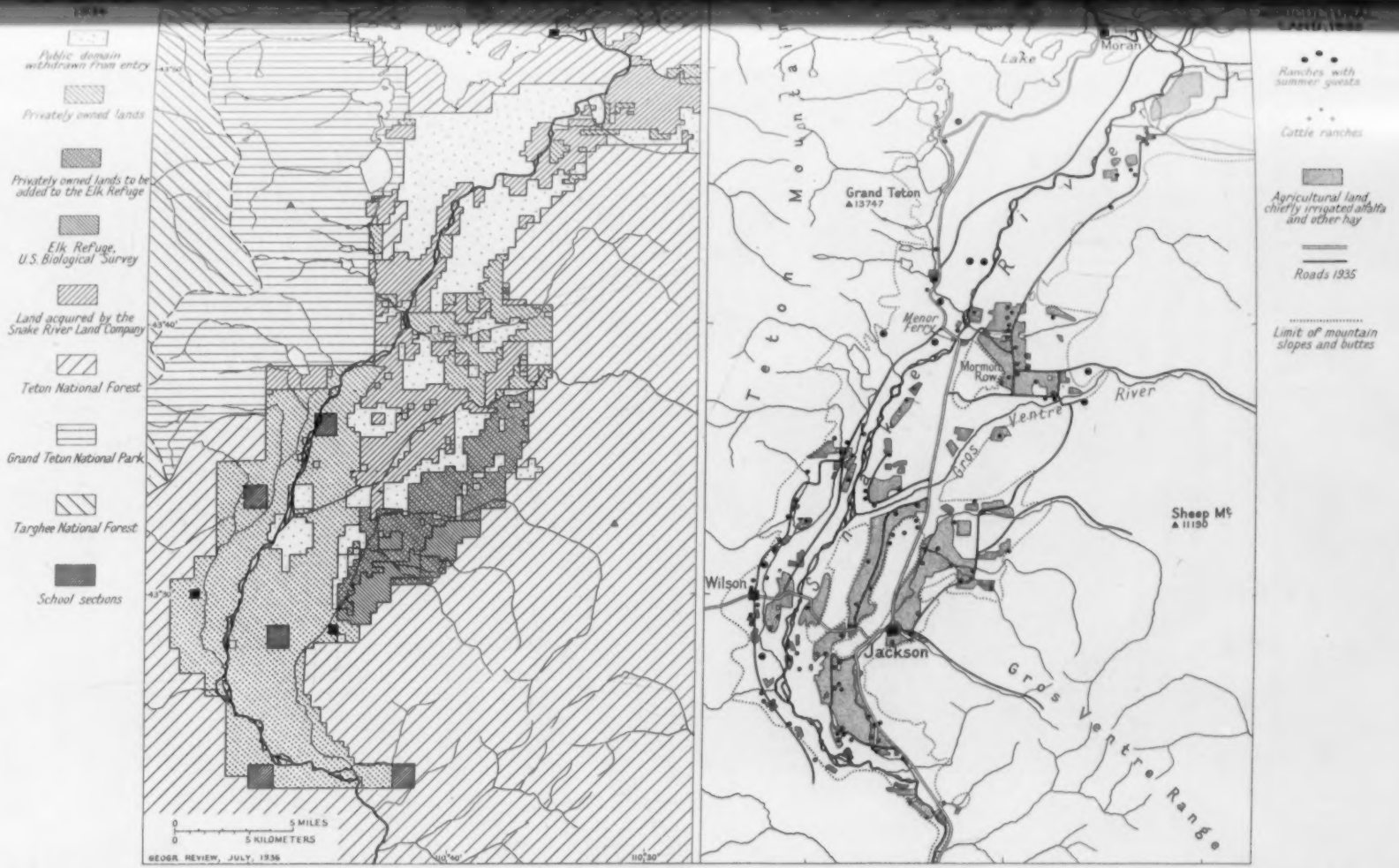

Public domain withdrawn from entry
Privately owned lands
Privately owned lands to be added to the Elk Refuge
Elk Refuge, U.S. Biological Survey
Land acquired by the Snake River Land Company
Teton National Forest
Grand Teton National Park
Targhee National Forest
School sections
43°40'
43°30'
0 5 MILES
0 5 KILOMETERS
GEOGR. REVIEW, JULY, 1936
110°40'
110°30'
Lake
Moran
Grand Teton
▲13747
Menor Ferry
Mormon Row
Gros Ventre River
Sheep Mt
▲11150
Wilson
Jackson
Gros Ventre Range
Ranches with summer guests
Cattle ranches
Agricultural land, chiefly irrigated alfalfa and other hay
Roads 1935
Limit of mountain slopes and buttes

FIG. 4

FIG. 5

These and other, smaller ranges, together with the high Yellowstone Plateau to the north, combine effectively to isolate the Jackson Hole country. Even the Snake River, which drains the basin, departs southward through a narrow, winding canyon.

This asymmetry of the east and west borders of Jackson Hole is a fundamental feature of the area. Within the basin itself there are

FIG. 6—The Teton Range, on the western margin of Jackson Hole, with pine-covered moraine in the middle distance. (Photograph by Crandall.)

corresponding contrasts between the eastern and western parts. On the west side the glaciers from the Teton Range extended beyond the mouths of the mountain valleys and left a number of marginal lakes behind morainic festoons along the mountain front (Fig. 2).[2] Glaciation was active in the Gros Ventre Range also, but because the cirques on this side lie so far to the east, the glaciers failed to emerge from the mountain valleys. From both sides came floods of coarse outwash gravels, which covered the floor of the Hole to a great depth; but those from the Gros Ventre side, being farther from the ends of the glaciers, contain a slightly larger proportion of fine material mixed with the cobble. Whatever may have been the original character of the basin floor, it was leveled off by this accumulation of gravel; only three steep-sided buttes stand conspicuously above the outwash (Fig. 11). Then, during the late stages of the Glacial period, a thin covering of loess fell, chiefly on the east side; and from some of the Gros Ventre valleys post-glacial alluvial fans are extending over the outwash. Thus the regolith on the east side is not quite so coarse as that on the west; and no rough morainic surfaces border the mountain front.[3]

[2] The field survey on which the maps are based was carried out during the summer of 1933. The author was assisted by A. J. Gray, O. E. Guthe, Eric Faigle, and L. J. Zuber.

[3] For an explanatory description of these landforms see Fritiof M. Fryxell: Glacial Features of Jackson Hole, Wyoming, *Augustana Library Publs. No. 13*, Rock Island, Ill., 1930.

The drainage, too, is asymmetrically developed. The Snake River, from the outlet of Jackson Lake to the south end of the basin where this river enters its canyon, forms somewhat of a median line, lying, however, a little to the west of the exact center. On its west side the river receives only short, turbulent tributaries descending almost directly from the relict glaciers high on the cirque walls; on its east

FIG. 7—The southern part of Jackson Hole, looking east from the road over Teton Pass. Note the contrast between the shady and the sunny sides on the Gros Ventre foothills in the background. (Photograph by E. Young.)

side, on the contrary, the Snake is joined by several large tributaries with extensive drainage basins, the largest of which is the Gros Ventre River.

THE COURSE OF SETTLEMENT

The occupance of this country by the cattle ranchers developed a pattern that also reflects this basic asymmetry. The first people to establish themselves permanently on the land came, in 1883, from the Mormon settlements of Utah and Idaho. Forming a back eddy in the prevailing westward course of migration, two families with a hundred head of cattle crossed the Teton Pass and entered what had been up to that time wild territory—a haven for hunters, trappers, and fugitives from the law. These first homesteaders crossed to the east side of the Hole and chose a place near the present site of the town of Jackson because there the heavy winter snows are not quite so deep as in the western and northern parts of the area and because of the presence of a natural meadow of wild hay (Fig. 3). The cattle herd passed the winter in the open on this meadow.

The following years saw a rapidly increasing stream of new settlers pouring into Jackson Hole. They came not only from the Mormon

group in Utah and Idaho but also from various parts of the eastern United States. The chief period of increasing population was from 1889 to 1909: by 1909 it was estimated that there were some 1500 people in the basin. Nearly all of them were cattle ranchers, feeding their animals during the summer in the Gros Ventre Mountains and maintaining them through the winter on wild or cultivated hay.

FIG. 8—Clearing the Hoback road. (Photograph by Barrett.)

For a number of reasons this ranching occupance followed the example of the firstcomers and concentrated in the eastern part of the basin (Fig. 5). Unfortunately snow measurements are not available for the various parts of the area, but local testimony confirms unanimously the statement that the snowfall is much deeper along the west side than on the east and somewhat deeper in the north than in the south. Then, too, the east side, where the supply of water is more abundant, can be irrigated in general more successfully. The Snake in its course through Jackson Hole is so deeply incised below the lowest terrace of the series cut by the river since the Glacial period that use of its water for irrigation is difficult here, and most of the local water supply must come from the tributaries. These, as has been pointed out, are largest and most dependable on the east side. Furthermore, the somewhat finer regolith on the east side of the basin retains moisture better.

In fact, the porosity of the regolith constitutes one of the chief problems of the agricultural use of the land. The climatic data available in the area, chiefly from Jackson and Moran (Fig. 5), indicate no deficiency of moisture. The average annual rainfall at Jackson for the period 1924–1933 was 15.3 inches (ranging from 11.7 in 1933 to 21.2 in 1930). At the relatively low temperatures of the area this amount is enough to class the station among the humid climates (Dfb

for Jackson, Dfc for Moran).[4] The natural vegetation on the outwash gravels is sagebrush, which in this case is edaphic rather than climatic in its requirement. Good stands of lodgepole pine mark the more compact glacial moraines (Figs. 3 and 6). This porosity of the outwash gravels requires the irrigation of cultivated hay in most parts of the area. Also, where irrigation has raised the water table almost

FIG. 9—Elk in the lower Gros Ventre foothills near Jackson Hole. (Photograph by Barrett.)

to the surface it has created new meadows of wild hay, similar to those that existed previously where natural conditions had created a high water table, as near Jackson (Fig. 3). In a climate really deficient in moisture such spots would have been ruined by the accumulation of alkali.

PROBLEMS AND PATTERNS OF CIRCULATION

The rectangular plan of the General Land Office has controlled the pattern of settlement in this country. To be sure, the first routes of travel were developed unsystematically across the sagebrush flats, shifting from time to time with changing currents of circulation. The topographic map, surveyed in 1899,[5] is of little use today as far as roads are concerned, so great has been the shifting. The fencing of the ranch lands increasingly forced the roads into the standard rectangular arrangement. The two main north-south roads, however, still preserve their irregular courses (Fig. 5).

Roads were built, and later improved, over the Teton Pass (8429

[4] Both stations are D′ in Thornthwaite's classification—humid, but deficient in temperature efficiency.

[5] Since this was written a revision of the Jackson Quadrangle has been issued, 1935. The U. S. Geological Survey also has in preparation a map of the Grand Teton National Park (scale 1 : 62,500). Use has been made of these maps in the drawing of the base for Figures 2 to 5. Incidentally the difficulties of representation of a braided stream, such as the Snake River, may be pointed out.

feet), the Rim (7921 feet), Togwotee Pass (9658 feet), and northward into Yellowstone Park (Fig. 1), but every winter they are blocked for five or six months by deep snows (Fig. 8). For many months the only contact with the outside world is by airplane. To reach a market in the fall the cattle are driven some thirty miles over the Teton Pass to the railroad at Victor, Idaho. The paving of some of these roads in recent years has been stimulated by the increasing number of automobile tourists entering Yellowstone from the south. In the winter of 1935–1936 funds to keep the Hoback and Teton Pass roads open the year round were made available for the first time.

The isolation of the area was the reason for the creation of Teton County with a county seat at Jackson. Although the population and taxable values were still well below the minimum required for the establishment of a county in Wyoming, in 1922 a special act of the state legislature gave the people of Jackson Hole a government center that they could reach throughout the year.

Wild Game

Meanwhile an important shift was taking place in the distribution of the wild game. The elk, originally a plains animal, were slowly being driven farther and farther into the mountains by the advance of settlement. Before the arrival of the ranchers in Jackson Hole a large herd of these animals was accustomed to spend the summer on the wild-hay meadows of the basin and on the north-facing slopes of the buttes and lower Gros Ventre foothills, where there are patches of aspen or pine shading a grassy floor. During the winter the animals migrated southward into the Green River country. By the last decade of the nineteenth century, however, the Green River basin had been occupied to such an extent that the elk were forced to seek even more isolated pastures. At the present time their migrations are fairly well fixed. During the summer they are found only in the higher pastures of the Gros Ventre Mountains or farther north, in the Yellowstone; but during the winter they seek refuge on the hay meadows of Jackson Hole, especially in places where they are fed, and on the south-facing slopes of the buttes and foothills (Fig. 9). As a result many of the slopes have been grazed bare of their scanty vegetation cover, and all are marked by the familiar terracelike trails. There is even more contrast now than formerly between the generally wooded shady slopes, which one sees in a view toward the south, and the very dry-looking sunny slopes, which one observes toward the north (Fig. 7).

The presence of this large herd of elk together with a great variety of other game animals and an abundance of fish gave the mountains and basins of western Wyoming a considerable reputation for hunting and fishing. Attracted by the wild life and also by the spectacular

natural scenery, an increasing number of people came to the area for recreation rather than permanent settlement. In fact, many of the later settlers first came as hunters. "Dude ranching" and hunting became important sources of revenue, in some cases independent of the cattle business, but more often as a profitable side line. One or two of

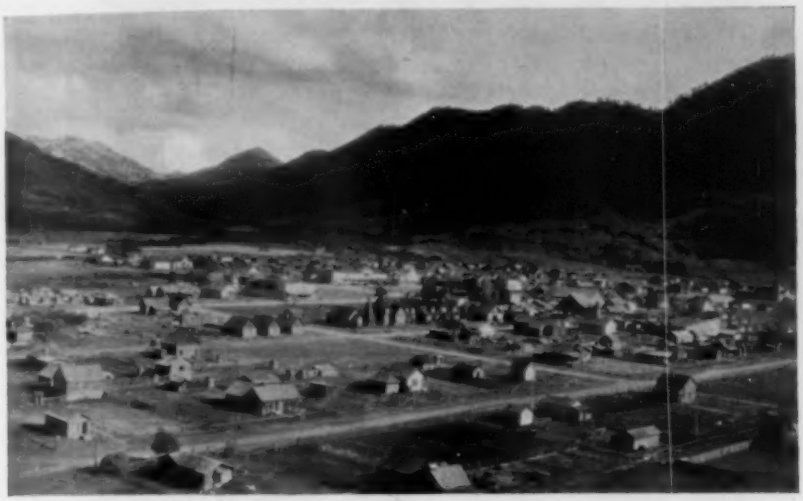


FIG. 10—Jackson, Wyoming: economic and political center of Jackson Hole. (Photograph by Sanborn.)

the dude ranches achieved a national reputation and attracted each year a number of eastern visitors of wealth and position. Climbers were increasingly drawn to the Tetons. "This superb range is at last coming into its own among mountaineers."[6] The beauties of Jackson Hole and its magnificent Teton Range were widely heralded.

PROJECTS FOR THE PRESERVATION OF THE NATURAL SCENERY

The various projects for preserving the natural scenery can be attributed largely to the eastern visitors. Unlike those of the Yellowstone country, these projects were conceived in the Jackson Hole region after ranching settlement had already become established—too late, therefore, for the acquisition of uninterrupted territory for recreational purposes. The supporters of the projects were, and are, obviously led by a variety of motives. Some are sincere idealists, filled with an almost religious zeal for the preservation of the natural scene—witness the little log chapel at Menor Ferry, with its plate-glass window behind the altar through which the majestic Tetons can be seen by the worshipers. Some motives, however, are more mundane. And the plans set forth are as varied as the motives. Some favor park extension; others are opposed to park extension but favor

[6] Fritiof Fryxell: The Teton Peaks and Their Ascents, 1932, p. 3.

some other form of administration for lands devoted exclusively to recreation. The original plan, it seems, contemplated the creation of a "national recreation area," to include the entire basin and its bordering mountains.[7] The plans actually put into operation, however, represent a compromise between this larger concept and the interests of those settlers who have resisted the movement to "buy them out."

These various recreational developments within the basin have had their most successful expansion on the west side. Some time before park extension was seriously discussed cheaper forms of recreation service had made their appearance, especially on the margins of the lakes at the base of the Tetons: a dance hall, a number of second-rate tourist cabins, a rodeo field, a succession of "hot-dog" stands along the highway, and the familiar advertisements. These things were not exactly in harmony with the background of forest, lake, and mountain. To many they constituted nothing less than a sacrilege; and much of the support for park extension sprang from a desire to eliminate them. In 1929 the Grand Teton National Park was created, with boundaries drawn to include the mountain peaks and the fringe of marginal lakes and moraines within Jackson Hole proper (Fig. 4).

The presence of these various recreational developments has had its effect on the pattern of circulation. Had Jackson Hole remained a purely ranching country, the main highway in all probability would have followed the east side of the basin. As it is now, the main surfaced road through the area follows the eastern route for part of the distance and the western route for the remainder. In the south the concentration of political and commercial interests serves to bring the main roads to a focus on the east side at Jackson (Fig. 10). But proceeding northward the main road crosses to the west side at the Menor Ferry Bridge, leads to the borders of the national park, and thence returns eastward to follow the eastern shores of Jackson Lake.

Meanwhile a considerable movement was on foot to provide increased protection and more winter feed for the now growing elk herd. As early as 1918 parts of the public domain not yet taken up by homesteaders were beginning to be removed from entry. Several subsequent withdrawals eventually closed to settlement most of the territory on the east side of the basin north of the town of Jackson. A bill in the United States Congress provided for the addition of a considerable area to the holdings of the Biological Survey, under whose care the elk herd was placed. The Survey, which deprecates the feeding practice as degrading, suggests the addition of more land for maintenance of the herd under natural conditions at about 20,000 head.[8]

[7] For an informative exposition of the plans see "Investigation of Proposed Enlargement of the Yellowstone and Grand Teton National Parks: Hearings before a Subcommittee of the Committee on Public Lands and Surveys, United States Senate, Seventy-Third Congress, Second Session, Pursuant to S. Res. 226 (72d Congress)," Washington, 1934.

[8] H. P. Sheldon, O. J. Murie, and W. E. Crouch: The Present Plight of the Jackson Hole Elk, *U. S. Dept. of Agric., Bur. of Biological Survey, Wildlife Research and Management Leaflet BS-12*, 1935.

These various plans and projects might have accomplished relatively little, however, had it not been for a gift of some two million dollars from Mr. John D. Rockefeller, Jr., for the aid of park extension. With the money the Snake River Land Company was incorporated, and through its agents it began the evaluation and purchase of ranching properties throughout the northern part of the basin, chiefly north of the Gros Ventre River. A large part of the settlement has now been

FIG. 11—Jackson Hole, looking west from the lower Gros Ventre foothills where the Gros Ventre River emerges into the basin. In the middle distance, Blacktail Butte with Mormon Row at its base; in the left foreground, a dude ranch. (Photograph by Crandall.)

removed from this territory—removed so completely that only when viewed from the air or from the summit of one of the buttes can the faint traces of the occupance patterns be discerned. A conspicuous though interrupted "island" of settlers has been left in so-called Mormon Row, on land that has been described as the most fertile of the whole basin.

Thus the normal course of settlement has been retarded. The cattlemen have found their summer pastures in the mountains restricted in favor of the elk; new settlers seeking either ranch lands or summer homes have found the public domain closed to entry: yet the groups interested in park extension have found a strong opposition on the part of those, especially, who realize that the withdrawal of so much land from the tax-paying category will render impossible the continuation of county government in Teton County. During the two decades from 1910 to 1930 the population of Jackson Hole increased only 480, to 1980, still below the 3000 required for the support of a county government. If a reservoir should be built flooding most of the land south of Jackson and Wilson, as is projected, and if most of the land north of these places should be cleared by the purchase and removal of settlement, the people left in between would be faced with considerable loss in valuations even if they were permitted to remain on the land. Whether the town of Jackson could survive solely on income from the summer tourists and fall hunters is a question.

Is Jackson Hole "Submarginal"?

Some of the proponents of park extension maintain that cattle ranching or other forms of farming activity cannot be carried on with financial success in Jackson Hole. The theory of the marginal producer, like most economic theories, is easy to set forth in general terms but difficult to apply in reality, largely because there are so many

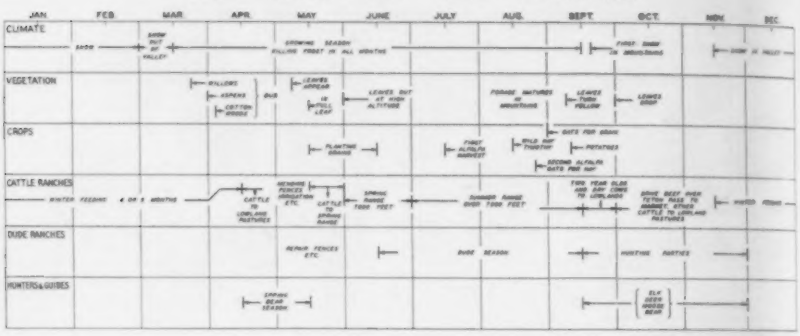


FIG. 12

"other things which are not equal." One approach to the problem, however, is to examine the existing situation and discover how it came about, the prediction of the future being left to others more courageous.

The difficulty with Jackson Hole, in addition to its isolation, lies in the length and severity of its winters. The snow does not leave the basin floor in the average year until early in May. The growing season is between the middle of May and the middle of September, but killing frosts may be feared, especially in the lower places along the rivers, during all months of the year. The first snows appear in the mountains in late September, and by the middle of November the basin floor is covered and the mountain roads have become impassable. At Jackson barely four months average above 50° F., and in most parts of the area there are only three months above 50°. During the winter the temperatures not infrequently drop below −30°.

The shortness of the growing season places Jackson Hole near the limits of agriculture. Yet parts of the basin have regularly and successfully matured vegetables and potatoes and such grains as wheat, barley, and oats. The most successful of such areas is the so-called Mormon Row. Located on the gentle slopes of an alluvial fan and on one of the higher gravel terraces, this area is especially free from early and late frosts. If spring rather than winter wheat is grown, it is not so much because of climatic necessity as the result of the depredations of the hungry elk.

Most of the agricultural land, however, is devoted to hay, and most of it is irrigated. Alfalfa is widely grown, but there is a con-

siderable acreage of wild hay where the water table lies at or close to the surface. The irregularly spaced and oriented haystacks, each protected from the elk by sturdy log fences, form prominent features of the landscape.

Aside from the hay purchased for the winter feeding of the elk, most of the crop is fed to the cattle. Feeding is necessary for four or

TABLE I—DATA ON SELECTED CATTLE RANCHES*

(In Jackson Hole and neighboring mountain valleys)

	NUMBER OF CATTLE		ACRES OF HAY LAND		HAY PRODUCTION (*Tons*)		ACRES OF PASTURE IN LOWLANDS
	1925	1932	1925	1932	1925	1932	1932
1	250	350	215	220	500	375	20
2	350	582	250	500	350	1000	720
3	170	150	200	100	275	212	40
4	200	275	270	300	300	420	100
5	54	100	100	100	140	170	60
6	600	1050	740	1100	900	1228	1200
7	90	130	100	150	100	150	290
8	200	350	350	380	600	800	260
9	220	355	480	480	500	490	80
10	160	150	150	160	250	112	120
11	74	55	135	120	90	75	200
12	90	90	100	150	204	315	290
13	75	100	300	200	150	300	300
14	80	80	250	300	200	225	360

Summary: Average acreage per head, 1.12; hay consumption per head, 1.54; hay production per acre, 1.38 tons; grazing land per head, 1.05 acres.

*Data are from U. S. Forest Service.

five months—from December to April (Fig. 12).[9] The cattle are driven to the spring range on the lower slopes of the Gros Ventre Mountains between the middle of May and the first of June. By the first of July they are on the summer pastures, where they remain until September or early October. The annual drive to the nearest railroad, at Victor, or to Opal, Wyo., 160 miles south in the Green River basin, takes place during October and early November.

Winter feed is the critical item in the cost of producing cattle in this area. On the average a ton of hay will carry a steer through an ordinary winter, though on fourteen selected successful ranches for which statistical information is available (Table I) about a ton and a half were consumed a head. The average yield of hay to an acre is about a ton, so that for the area as a whole about an acre or perhaps a

[9] For aid in the preparation of Figure 12 and for advice and assistance in the collection of other information the author is indebted to the District Forest Ranger, Mr. F. Buchenroth.

little more than an acre of irrigated hay land to a head of cattle is necessary. Again the figures for the fourteen selected ranches are a little higher than this.

According to a report of the supervisor of the Teton National Forest,[10] using 1932 figures, there were 7827 head of cattle from Teton County, which means practically Jackson Hole, summering in the national forest. There were also 6000 head from outside areas. Even this, however, represented only 80 per cent of the capacity of the forest for summer grazing. The forest supervisor suggested increasing the Jackson Hole cattle herd by some 3000 head and, in addition, in order to utilize the total possible amount of hay land, increasing the number of dairy cattle summering as well as wintering in the Hole by some 2000 head. This plan, however, would require the use of all the irrigable land, a large part of which has been removed from production by the activities of the Snake River Land Company.

Whether or not the ranchers can make a profit depends not only on the physical possibilities of the region but also on the energy and ability of the operators and on the price in the outside markets. Although a number of the ranches were financially embarrassed and so were glad to sell to the Snake River Land Company, most of them were making a clear profit, according to the testimony of the Jackson banker.[11] Interviews with several of the successful ranchers yielded the estimate that cattle from Jackson Hole could be placed on the market without losing money as long as a price of 6 cents a pound could be obtained.

This evidence seems to indicate that Jackson Hole can scarcely be considered submarginal from the point of view of the cattle producer. It is not listed as a problem area by the Department of Agriculture. But what other, more intensive forms of land use could be developed? Here again we are forced to fall back on estimates supported by the evidence of what has actually been accomplished. The area seems to possess all the necessary climatic requirements for producing first-class butter and cheese. In 1934 a coöperative creamery was opened in Jackson, and Jackson butter now finds a steady and increasing market in towns outside the basin. However, there is agreement that the dairy business in order to prosper must enlist the services of men trained in dairy work. Beef-cattle producers make notoriously poor dairymen. There is reason to believe that, if conditions of settlement were more favorable, experienced dairymen would be attracted to the region.

"Dude ranching" and the development of summer homes are also forms of land use that would have a considerable growth in the Hole

[10] A. C. McCain: Economic Survey of Jackson's Hole and Plan of Development, Jackson, 1933. (In manuscript.)

[11] Investigation of Proposed Enlargement of the Yellowstone and Grand Teton National Parks (*op. cit.*), p. 65.

if the territory were still open to settlement. A large number of applications for the construction of summer homes, especially along the shores of Jackson Lake, have been filed away by the Forest Service. It is stated that if these applications had been granted the taxable values in the county would have been increased enormously.

Conclusion

So it is that for more than a decade now the process of settlement in the Jackson Hole country has been stalled. Neither of the two opposed plans for the area has been able to gain a clear decision and the chance to proceed without interruption. Any decision one might make is likely to be colored by the preconceptions one brings to the problem. To the outsider the concept of a wide extent of territory returned as nearly as possible to its natural state has a strong appeal, especially when one views by comparison the devastated landscapes of the lumbering and mining areas of our western states. But there are real difficulties involved in the creation of such a territory after settlers have already become attached to the land.

THE TOPOGRAPHICAL RESULTS OF ELLSWORTH'S TRANS-ANTARCTIC FLIGHT OF 1935

W. L. G. Joerg

HEREWITH are presented the topographical results of Lincoln Ellsworth's Antarctic flights of November 21 and November 23–December 5, 1935. They are based on the original material generously placed at the American Geographical Society's disposal by Mr. Ellsworth, consisting of a complete set of the photographs taken by him and the observational and navigational records kept by him and his pilot, Mr. Herbert Hollick-Kenyon, on the two flights.

The Flight Tracks

As described in the April, 1936, *Geographical Review* (pp. 329-332), the flight of November 21 proceeded from Dundee Island to and just beyond Stefansson Strait and then returned to its starting point, whereas the flight of November 23 to December 5 crossed the entire length of West Antarctica from Dundee Island to Little America (Fig. 1). The tracks of these two flights were plotted on the Society's map of the Antarctic on the scale of 1 : 4,000,000 from the courses, indicated air speeds, drift, and other data in the logs. It is likely that the track of the trans-Antarctic flight is nearly correct, since the astronomically determined position of the third landing,[1] on November 27 in 79° 58′ S. and 114° 15′ W., made it possible to tie it down at this point between its two known ends, and only minor adjustments had to be made in fitting the indicated courses and air speeds into the eastern segment and no adjustments had to be made in the western segment. Less confidence is held in the representation of the loops in the track of the November 21 flight in the Stefansson Strait region (top of Fig. 1), inasmuch as no courses or speeds were recorded after the second (westward) passing of Cape Eielson in this difficult flying terrain. It was only the recognition of identical features on photographs taken on both flights (Figs. 2, 3, 4) that gave some clue to the relation of the November 21 track to the relatively definite November 23 track. The plotting of both flights, however, in their southward approach to the mainland, agreed well in the resulting position of the important point Cape Eielson. Both tended to place it in about 70° S. and 64½° W. In latitude this agrees with Sir Hubert Wilkins' original reconnaissance position;[2] in longitude it is 2° to the west of that position, but this shift seems on the whole to fit

[1] The astronomical positions of the first and second landings as published in the newspaper report and on p. 331 of the April *Geographical Review* were calculated back from the third landing, since it was later found out that the original determinations were incorrect owing to a loose screw on the sextant.

[2] *Geogr. Rev.*, Vol. 19, 1929, Pl. IV. See also note on Pl. IV and reference to reliability of latitudes and longitudes, p. 376.

better the mountain structure revealed by the Ellsworth flight, as will appear.

The Photographs

The photographic material bearing on topography consisted of two series of Leica film, one of 25 exposures (each 24 x 37 millimeters) relating to the November 21 flight and the other of 41 exposures relating to the November 23 to December 5 flight. Neither series contained any photographs taken north of the Stefansson Strait region, and the last exposure in the second series (all were made on November 23) was made in about 77½° S. and 92° W. Of both series Mr. Ellsworth had made a list giving the time when each photograph was taken and whether from the right or the left side of the airplane. The flying height of the plane was as a rule available from the log.

Enlarged prints 4 by 6 inches in size were made: these were studied for coincident features, and the position and direction of each photograph were plotted along the time spacing on the routes according to the record on the list.[3] As a result, the photographs fell into groups naturally,[4] and this grouping and additional notes in the logs relating to features not shown on the photographs made it possible to reconstruct the major lineaments of the area traversed and classify them regionally.

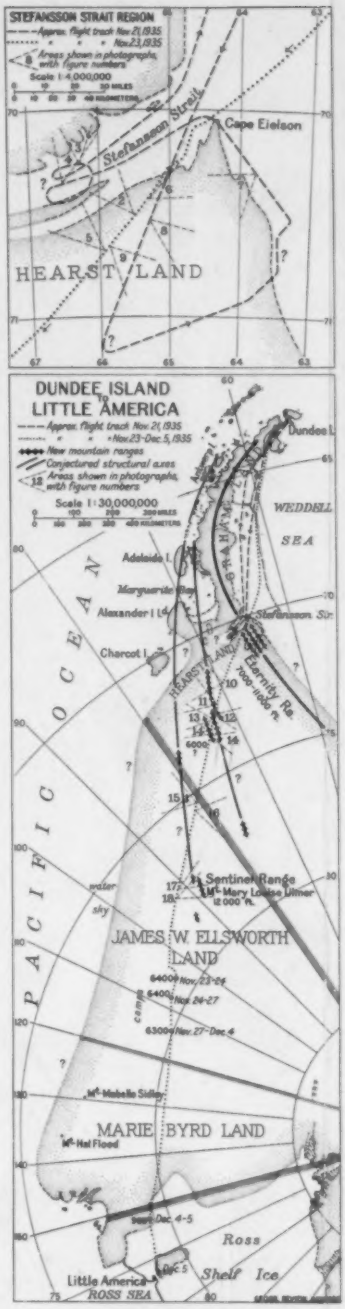


FIG. 1—Sketch map showing the location and direction of the photographs illustrating the article and the conjectured trend of the mountain axes of the Antarctandes.

[3] The photographs, consisting usually of individual exposures or, if in a consecutive series, of exposures made at one-minute intervals, did not as a rule lend themselves to the methods of cartographic reduction applied to the photographs of the first Byrd Antarctic expedition by O. M. Miller (*Geogr. Rev.*, Vol. 21, 1931, Pl. I and pp. 201–212) and H. E. Saunders (*ibid.*, Vol. 23, 1933, Pl. II and pp. 195–209).

[4] Of each of these groups at least one representative photograph is published herewith. Figures 2 to 18 hence encompass the whole range of topographical features observed on the flights.

FIG. 2—Looking about northwest across the Stefansson Strait depression. Letters indicate identical features on Figs. 3 and 4. (13,0 feet; 12:45. Approximate altitude of airplane and Greenwich mean time on November 23, 1935, are given thus.)

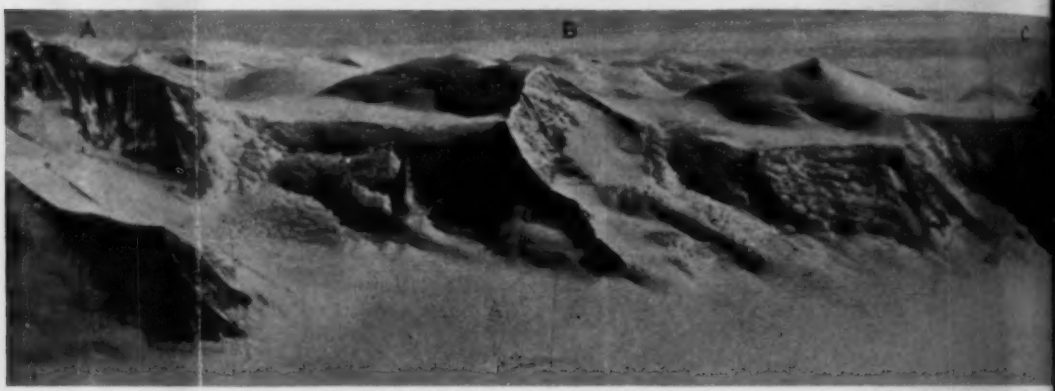


FIG. 3—Close view of the cirques, truncated spurs, and hanging glaciers of the northern mountain wall of the Stefansson Strait depres shown on Fig. 2. (Altitude and time not given—possibly 3000 feet; Nov. 21, about 15:15.)

FIG. 4—Looking about northeast along the northern coast of the Stefansson Strait depression. The embayment in the right mid distance may also be identified on Fig. 2. (Altitude not given—possibly 4000 feet; Nov. 21, 14:52.)

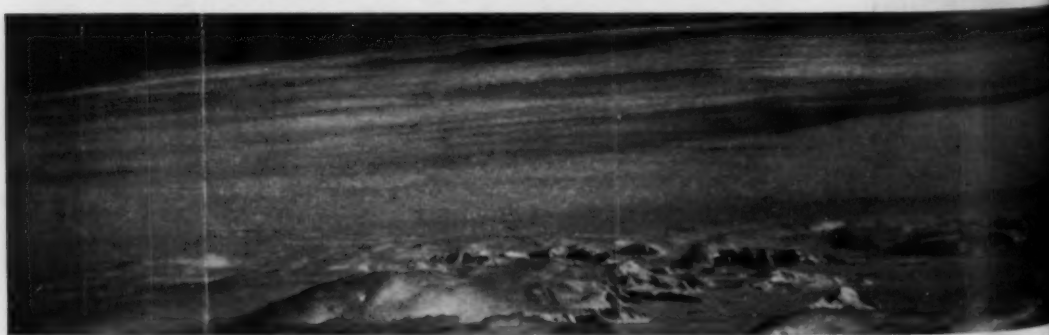


FIG. 5—Cloud-filled western part of the Stefansson Strait depression (probably slightly overlapping and continuous with left end of F 2). (13,000 feet; 12:59.) This may be toward the head of the depression, if the non-existence of a through strait is confirmed that Rym

Fig. 6—Looking northeast across headlands of the ranges terminating on the southern side of the Stefansson Strait depression. Cape Eielson, the northernmost of these headlands, probably lies behind the ridges in the middle distance. (13,000 feet; 12:40.)

Fig. 7—View probably looking southwest from over the Weddell Sea coast about 20 miles southeast of Cape Eielson across one of the longitudinal valleys and ranges forming part of the same system as those on Fig. 6. (9600 feet; Nov. 21, 14:00.)

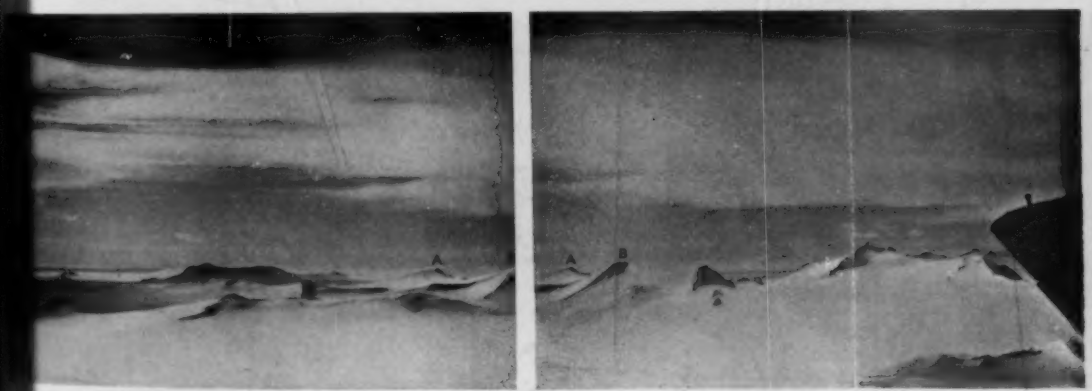


Fig. 8—Looking southeast over the summit peaks of the main axis of that system (termed Eternity Range by Mr. Ellsworth), about 40 miles southwest of Cape Eielson. Overlapping identical peaks indicated by letters. (8500 feet; Nov. 21, 12:20.)

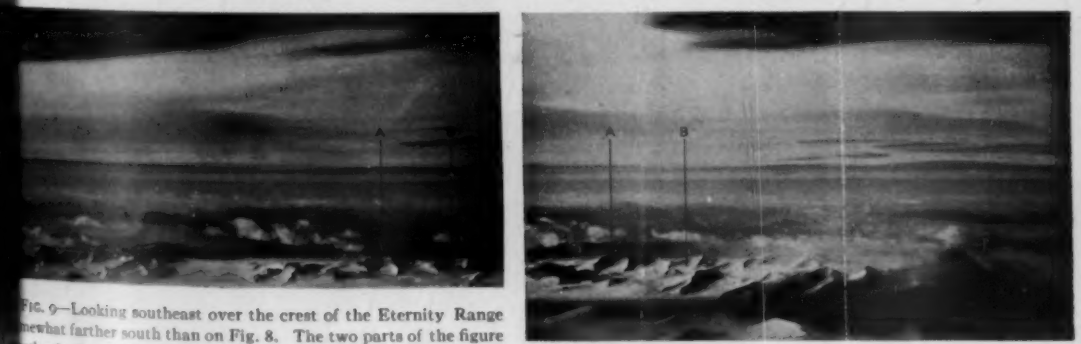


Fig. 9—Looking southeast over the crest of the Eternity Range somewhat farther south than on Fig. 8. The two parts of the figure overlap in the middle, as indicated by the identical cirques lettered A and B. (13,000 feet; 12:57.)

All photographs copyright by Lincoln Ellsworth

FIG. 10 (across spread of pages)—View northwest toward north-south trending range probably lying in about 71° W. between 71½° and 73¼° S. The range, whose northern end is seen in the distance in the middle of the right picture, sweeps toward the observer in the le

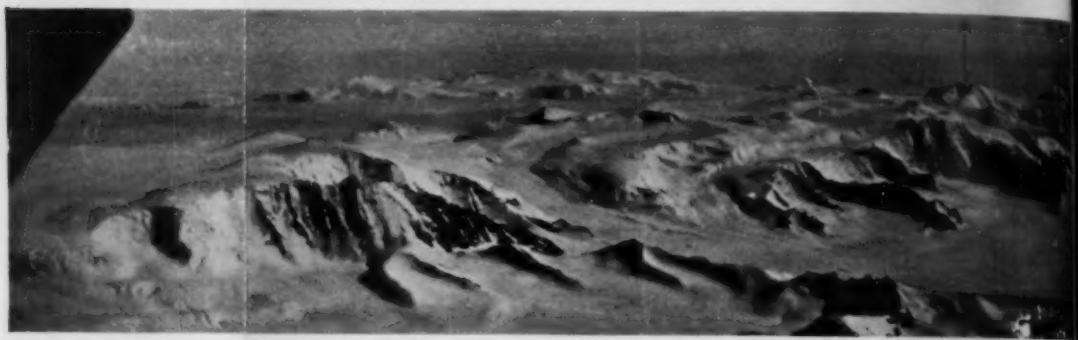


FIG. 11 (across spread of pages)—Near view, looking northwest, of the range shown in Fig. 10, as the airplane was crossing it in abou 71½° W. and 72½° S. Identical features on the overlapping sections are lettered to correspond. The wide, open glacial valley in the righ

FIG. 12—View southeast probably showing, in the distant left, the southern end of the range shown in Figs. 10 and 11. The foreground range (note stratification) probably ends in the ice-buried ridge appearing in background of Fig. 14 (left). (10,000 feet; 15:05.)

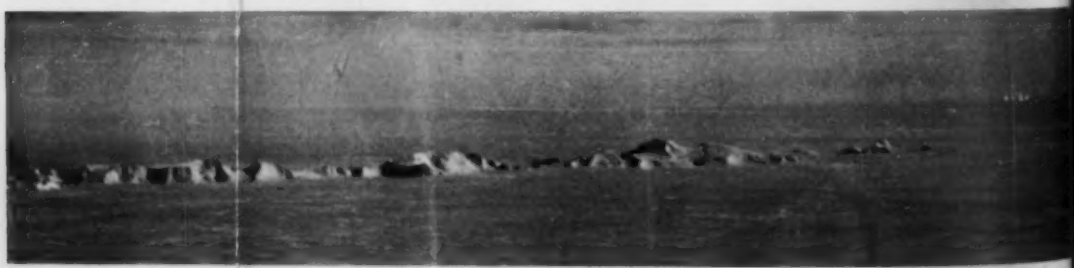


FIG. 13—Looking northwest toward the northern end, protruding from a cloud bank, of a range that probably lies in about 73½° W. and between 72¾° and 73¾° S. (10,000 feet; 15:12.)

FIG. 14—Looking southeast (left) and northwest in about 73½° W. and 73½° S. along a range (probably the same as in Fig. 13), constituting the westernmost in the conjectured intermediate axis (see text). (9800 feet; 15:30.)

reground of the left picture. The adjoining photograph to the left (not published) displays sedimentary rocks that dip about 10° to the uthwest. (11,200 feet; 14:13 and 14:18.)

cture is characteristic of the range (another appears on the unpublished photograph continuing Fig. 10 to the left). (10,000 feet; about 3:50.)

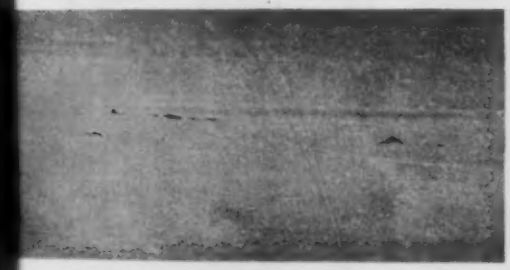


FIG. 15—Icecap with nunataks, typical outside of the mountain ks. Looking NW from 80° W. and 75¼° S. (10,000 feet; 17:18.)

FIG. 16—Isolated nunatak seen southeast from about 81° W. and 75½° S. (9,600 feet; 17:32.)

FIG. 17—The Sentinel Range, which lies in about 88° W. and between 77¼° and 78⅓° S., looking southeast from about 91° W. and ¾° S. A shorter range that lies in front of the left (northeastern) end has been silhouetted with a black line. (10,000 feet; 19:30.)

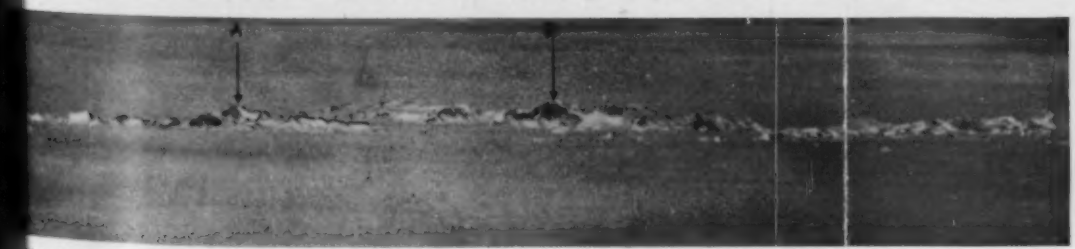


FIG. 18—The Sentinel Range from a point 25 miles southwest of the point whence Fig. 17 was taken. (10,000 feet; 19:44.) Mt. Mary uise Ulmer is the highest peak in the main range.

Stefansson Strait Region

A general result of the flights seems to be to compress Stefansson Strait and shift it northward as compared with Wilkins' reconnaissance map. Its eastern entrance seems to lie mainly north of the 70th parallel, and the average width of the whole depression between Scripps Island and the mainland seems to be 20 to 25 miles, as compared with the 60 miles or more of the Wilkins map. From the Ellsworth photographs, of which Figure 2 is the most comprehensive, it is not possible to identify with certainty Lurabee Channel, the Finley Islands, and Stefansson Strait proper or to correlate them with Wilkins' photographs of these features.[5] The fact that toward the west the Stefansson Strait depression was filled with clouds on November 23 (Fig. 5) might point to the presence of higher land in that direction, as was first reported by Wilkins himself from his flight to Charcot Island on December 29, 1929, and as was recently confirmed by Rymill from his flight on March 13, 1936, to a point 75 miles southwest of his base on the east coast of Marguerite Bay in 68° S. Wilkins reported[6] two areas of high land that he interpreted as islands in about 70° S. and 68½° W. and 70⅓° S. and 69½° W. Rymill reports[7] Marguerite Bay as closed to the south by 7000-foot mountain massifs. These discoveries might indicate that Stefansson Strait is not a strait at all but merely one of the embayments—a major one, to be sure—into which the glaciers of the eastern side of Graham Land discharge.

The Antarctandes

South of the Stefansson Strait depression the results of the Ellsworth flights seem to confirm not only the conjectured southern continuation of the Antarctandes but also the virgation, or spreading, of their axes forecast by the Swiss geologist Staub.[8] The significance of this virgation would be that it represents the only one of the two blind ends in which the great world belt of young folded mountains frays out to the south that impinges directly on the oldland mass of Antarctica, since the other, the New Zealand–Auckland Islands–Campbell Island virgation, dies out before it reaches the southern continent.

Although all deductions must necessarily be tentative, it may be pointed out that the ranges discovered on November 21 and 23 south of Stefansson Strait seem, in orientation and position, to fit into the prolongation of the three axes recognizable north of the strait.

[5] *Geogr. Rev.*, Vol. 19, 1929, Figs. 29–34 on pp. 368–369.
[6] *Geogr. Rev.*, Vol. 20, 1930, Pl. III and pp. 373–374.
[7] *London Times*, April 17, 1936 (also weekly edition, April 23, 1936).
[8] Rudolf Staub: Der Bewegungsmechanismus der Erde, Berlin, 1928, pp. 117–118 and map in pocket. On the underlying concepts of geotectonics see Staub, pp. 7–21, and W. H. Bucher: The Deformation of the Earth's Crust, Princeton, N. J., 1933.

The main range discovered south of Stefansson Strait, named Eternity Range (Figs. 8 and 9), which reaches an elevation of 11,000 feet, forms a direct continuation of the main axis of Graham Land. It has a south-southeast trend and consists of a number of subranges whose northern ends and intervening longitudinal valleys are truncated by the Stefansson Strait depression (Fig. 6). Its eastern border, at least in the area observed, seems to form the western coast of Weddell Sea. The westward shift of Cape Eielson, at the northern end of this coast, mentioned above, brings the Weddell Sea coast into plausible alignment with the Graham Land coast north of the strait.

What may be termed the intermediate axis, defined by the islands west of Lallemand and Bourgeois Fiords (67½° W., between 67° and 68° S.) and by the mountain "islands" discovered by Wilkins and Rymill south of Marguerite Bay, seems continued to the south by three ranges trending north-south lying between about 71° and 74° W. and 71½° and 73½° S. (Figs. 10–11–12, 12–14, 13–14). Mountains seen to the south 120 to 140 miles from the November 23 track in about 81° W., and therefore lying in about 77° S. and 76° W., may also belong to this axis.

In the third, or western, axis, defined by the offshore islands Antwerp, Adelaide, and Alexander I (Charcot Island is off line), would lie the high Sentinel Range, discovered in about 88° W., between about 77° and 78° S., with its 12,000-foot peak Mt. Mary Louise Ulmer (Figs. 17 and 18),[9] and a range located in about 92° W. and 78½° S. Nearer the coast, in the same alignment, may lie the mountains seen to the right from 77° W. on the November 23 track, which would place them in about 79° W. and 73½° S.

Between the first and second and the second and third axes the plain of the icecap, averaging 6000 feet in height, is interrupted only by occasional nunataks (Fig. 15).

Ice-Covered Plateau

Beyond the last mountains, in 92° W. and 78½° S., the icecap extends apparently without interruption to the Ross Shelf Ice. From 92° to 115° W. it maintains a level of more than 6000 feet. In 115° W. it begins to descend and decreases to 4500 feet at about the 127th meridian and to 1000 feet near its termination at the shelf ice in about 149° W. and 79⅔° S., where the flight route crossed it.

Objectives for Future Exploration

From this brief account it will be seen that in one remarkable flight of 2200 miles, of which 1200 miles were over wholly unknown

[9] Owing to the smallness of the Leica exposures, which were the only prints available to the members of the expedition for identification at first, the range in 73° W. and 73° S. shown in Figure 14 was confused with the Sentinel Range. The one in 88° W. and 77½° S. shown in Figures 17 and 18 is the one to which Mr. Ellsworth gave the name and to which he wishes it to apply henceforth.

territory, a clue has been gained to the character of one of the earth's important structural areas. Enough has been seen to show that here, in this tapering projection of the continent between Weddell and Ross Seas, the interior of the icecap, unlike its counterpart of the same size in Greenland, does not completely mask the underlying topographical features. Further exploration is therefore likely to yield immediately tangible results: following the Eternity Range to the south will disclose the behavior of this major trend line and its relation to the probably shelf-ice-fringed west coast of Weddell Sea; following the other axes or crossing them farther south may throw light on their termination and their relation to the old mass of the rest of the continent; and tracing the coast on the Pacific Ocean side may confirm the inward sweep to the south (Fig. 1) suggested by the water sky observed by Hollick-Kenyon on November 23 in the conjectured position of 76° S. and 100° W. and also by the marginal location of Mt. Hal Flood and Mt. Mabelle Sidley surmised by Harold June on the flight eastward to 135° W. on the 78th parallel on November 18, 1934, during the second Byrd expedition.

THE RAINFALL REGIME OF THE WESTERN PLAINS

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MODERN climatic studies must be founded essentially on methods of statistical generalization. The part played by numerical material in climatology has been progressively widened in recent years, but the methods of generalizing therefrom have remained substantially unchanged. It is the object of this paper to show that the technique so far employed has by no means exhausted all the possibilities.

If we turn to an old classic, such as Julius Hann's "Handbuch der Klimatologie," we find that much of the reasoning is based on inference and the records of individual experience. There is a wealth of tabulated data, carefully annotated and authenticated, but it is included as illustration rather than as source material. Seen in this light its omission would be a loss to the work but would not vitiate the whole structure. It is becoming a common modern practice to relegate tabular data to an appendix.

Köppen's classification of climates on an arithmetical basis has been much admired as an exercise of ingenuity, but it has not been adequately realized that a fundamental change of outlook was involved. Köppen took climatic normals from the façade of the science and placed them in vital structural locations. It is true that definitions were arrived at by a skillful combination of empiricism and improvisation that obscured the change of outlook. Yet the fact remains that the instant a definition on an arithmetical basis finds acceptance, the data concerned are placed in a new light. It is not argued that the change was not progressive—far from it; but it is maintained that it should have been accompanied by a most searching examination of the character of the material available. Illustration may be as sketchy as we please as long as it is effective, but source material should be as sound as it can be made.

Still further developments in modern thought involve the concept of variability. Climatology no longer confines itself to "average weather" but takes a keen interest in the frequency of exceptional weather. If we are to accept without reservation the dictum of R. J. Russell that "climates are not constant in position and it is fallacious to regard them as being so," then the search for any valid mean expression would seem foredoomed to failure. Climatic statistics must therefore be examined in their entirety, and obsolete normals must be replaced by indices of probability. The dependence of the science on its numerical foundations is thus proportionately increased.

The progressive nature of these aspirations has found little reflection in the conservative methods so far employed. Köppen and Russell have their eyes on a far horizon, but it is questionable whether their means of travel is an improvement over that of the pioneers. The twin dangers to which both studies are liable are the biased errors inherent in the arithmetic mean and the temptation to beg the whole question when phenomena are submitted to subjective examination. Neither of these dangers would seem to offer much difficulty when squarely faced; but the more elaborate and refined the subsequent analysis, the easier it is to overlook initial limitations. The ideas implicit in both views would seem capable of being carried to a logical conclusion only if we take the step to a vehicle of more flexible and accommodating construction. The present paper is an attempt to design such a vehicle for the study of precipitation. The conception of a general climatic regime is retained, but it is itself allowed to emerge from a study of frequencies. The norm is no longer contrasted with the variant, but both appear in perspective as elements of probability. The analysis is strictly objective, and no notions of "adequate" and "critical" rainfalls are allowed to find a place in the main structure. The Great Plains of North America west of the 97th meridian are selected in view of the unique records available across a broad continental zone of evident climatic transition. Although the method employed has already been outlined in connection with a European example,[1] the present test lends itself to further developments and finer distinctions. The technique is elementary, and the instrument is only a rough one, but it offers a challenge in principle to traditional methods.

Rainfall Regime

The conception of regime in geography postulates the existence of an orderly sequence in the course of events. The essential feature is the degree of change experienced between one period and another. Where such a "rule" lies concealed under innumerable day-to-day variations it may be necessary to make the period of reference as long as a whole month; hence the practice of expressing climatic regime by the use of twelve monthly means. So far there is no fault to find in the traditional approach. Even the inequality in length of the calendar months is scarcely enough to affect broad geographical considerations.

Errors have arisen from two chief sources: the choice of the arithmetic average to provide the necessary mean and the classification of regimes on the crude basis of maximum and minimum values alone. Probably the latter is the greater of the two evils, and it will come in for first consideration.

[1] P. R. Crowe: The Analysis of Rainfall Probability. *Scottish Geogr. Mag.*, Vol. 49, 1933, pp. 73–91.

In view of the marked developments that have taken place in the presentation of the twelve monthly rainfall normals, from Hann's tables through variously elaborated types of graph to the composite curve of pluviometrical fractions of Angot and Ward, it is surely remarkable that the principles of classification have made no progress whatsoever. Having its origin apparently in the use of distinctive type for maximum and minimum values in the "Handbuch," the idea that these values are in some obscure fashion worth more than the others seems to have dominated a long line of eminent climatologists. The expedient was perfectly justified in its original purpose of assisting the eye in ready appreciation of a column of figures. It should have been jettisoned when we began to think in terms of curves. Surely one of the most important facts about a graph is its gradient, or rate of change. This is momentarily nil at the maximum and minimum values and so is completely ignored in the traditional basis of classification. No study of the dynamics of rainfall can surely be adequate unless it gives some consideration to the intermediate points of the curve, where the rate of change is most rapid. It is a useful little exercise to plot monthly normals on a logarithmic scale.

This view is confirmed when it is appreciated that averages are not absolute quantities but merely rough indices with a calculable degree of error. The error depends on the scattering of the values of which the average is a summary. In the case of monthly rainfall data mean dispersion may be of the order of 30 to 60 per cent. Is it not clear then that where differences between monthly normals are slight, the actual position of a maximum value may be very much in doubt. Possibly three or more consecutive months may have a more or less equal claim. It is a valuable practical consideration therefore that the period of most rapid change, occurring where the differences between adjacent months are greatest, is less likely to be in doubt from this cause. It is worth recalling Sir Napier Shaw's dictum regarding all curves of this type that "a node is a much better defined point than a maximum." Much ingenuity spent in contrasting May with June maxima and in seeking causes for apparent "secondary maxima" has therefore been an intellectual form of shadowboxing! These values are neither typical nor critical; their distinction is purely a matter of arithmetic and, as such, has no geographical quality. Natural phenomena must be analyzed by a study of all the facts, and, whatever system of shorthand may be devised to make that possible, it must be both comprehensive and flexible.

The Dispersion Diagram

Graphical methods form probably the most effective way of introducing these new considerations into the field of climatology.

A definite advantage is that they claim no further validity than is evident at face value. The method employed here can be stated briefly. In essence it regards the series of rainfal values for each month over a long period of years as a frequency group that can be summarized by locating median and quartile values (terms defined in any elementary handbook of statistics). Three values instead of one are thus plotted against each month. The median gives a central point or mean expectation of rainfall, and the distance between the quartiles, shaded to make it effective, measures the mean range of variation about it. Obvious advantages over the arithmetic normal are: (1) amounts as large as the median occur, by definition, in precisely half the years—the position has some reality; (2) the shaded area is a constant warning against false accuracy.

As the relative position of medians and quartiles for two months clearly gives some indication of the rapidity of the change experienced, it is argued that at some stage or other in the relationship we must be able to regard the difference as "significant." A convenient working hypothesis is to regard contrast in the precipitation of two months as justified only when the median of each falls very near or beyond a quartile of the other. Between adjacent months differences of this amplitude are relatively rare. They have therefore been taken to represent some form of break in continuity. It is not intended to suggest that such a "break" implies violence of transition, but it is insisted that such features must be of real significance. However rough-and-ready the touchstone may prove to be, it is clear that it must give a more precise view of regime than no criterion whatever.

Significant Changes or Rainfall Discontinuities

The assertion that the question of the significance of the difference between two averages can be handled, at least in broad outline, by graphical methods would seem to be incapable of systematic proof. The whole matter is a question of probability, of taking a reasonable view. Even the mathematical approach is not wholly free from assumptions. It becomes necessary therefore to back our hypothesis with such evidence as can be mustered in its favor. Three lines of attack will be employed: (1) application of the method to an alternative field where the facts are more obvious; (2) comparison of results with those of an alternative approach; and—for the benefit of those who prefer to think in symbols—(3) brief theoretical speculation.

TEMPERATURE DISPERSION

Precipitation and temperature are compared by dispersion diagrams for North Platte, Neb. (1881–1930) in Figure 1. A marked contrast in the scattering of temperature and rainfall values is obvious. The quartiles enclose the most centrally placed half of the values

in each month, and the degree of overlap between adjacent columns varies remarkably. In the rainfall diagram no single month has a quartile range that is completely free of that of the months immediately following or preceding it. Precipitation regime must obviously be a much more indefinite conception than temperature regime. There

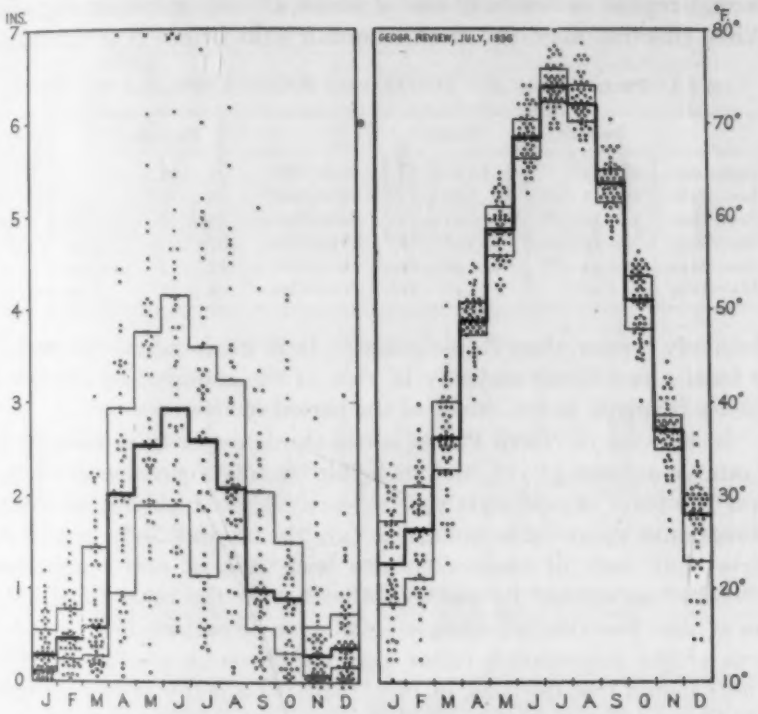


FIG. 1—Dispersion diagram for precipitation and temperature for North Platte, Neb.

is an element of doubt as to whether July or August is the hotter month and some uncertainty regarding the arrival of really cold spells in midwinter, but no resident observer could have much doubt of the relative positions of April and May or of September and October. Temperature regime is thus so definite that it is easy to check it against practical experience. Ask the man in the street, on the other hand, whether May, June, or July is the rainiest month, and the answer will be far from confident. Only a climatologist will reply without hesitation, "June"; and that is because he has been trained to think in terms not of experience but of scientific fiction!

THE METHOD OF FREQUENCY RATIOS

The fundamental difficulty is that, although the average for June may be the greater over a period, it is by no means unlikely that May will have recorded more than June in a very considerable number of

the years. Average amount gives only the slightest indication of frequency. Frequency is clearly of considerable importance. Count the number of years when June rainfall actually exceeded that of May and compare it with the number when the positions were reversed. Continue the process with other pairs of adjacent months until the annual regime is resolved into a series of twelve frequency ratios. What effective majority must a month gain before it is considered

TABLE I—PRECIPITATION AND TEMPERATURE RATIOS, NORTH PLATTE, 1881–1930

	PRECIP.	TEMP.		PRECIP.	TEMP.
Dec.-Jan.	26 : 24 .	31½ : 18½ . (?)	June-July	32 : 18 . (?)	2 : 48 . (x)
Jan.-Feb.	19 : 31 . (?)	15 : 35 . (?)	July-Aug.	25 : 25 .	32 : 18 . (?)
Feb.-Mar.	18 : 32 . (?)	9 : 41 . (x)	Aug.-Sept.	38 : 12 . (x)	49 : 1 . (x)
Mar.-Apr.	9 : 41 . (x)	2 : 48 . (x)	Sept.-Oct.	30½ : 19½ . (?)	50 : 0 . (x)
Apr.-May	17 : 33 . (?)	0 : 50 . (x)	Oct.-Nov.	37 : 13 . (x)	49 : 1 . (x)
May-June	22 : 28 .	1 : 49 . (x)	Nov.-Dec.	25 . 25 .	48 : 2 . (x)

definitely wetter than its neighbor? Is it unreasonable to demand at least a two-thirds majority in view of the considerable element of chance involved in the choice of the period of reference?

In the case of North Platte, a two-thirds majority is indicated by a ratio of at least 33 : 17, and negligible contrasts correspond to ratios near the point of equilibrium, viz. 25 : 25. The temperature column shows nine appreciable contrasts (x), the rainfall data show only three, but each of these coincides with rainfall and temperature "breaks" as defined by our hypothesis. On the other hand, there are at least four rainfall ratios so small as to be entirely fortuitous, but none of the temperature ratios would seem to be wholly negligible. This random example has, in fact, rather too many borderline cases (?), whose ultimate destiny will depend on just precisely where the distinction is to be drawn. There is no justification for expecting exact correspondence between the verdicts of the dispersion diagram and the frequency ratio, but even this single case reveals that there is a good deal of common ground between them. It will probably come as a surprise to those with a too rigid idea of rainfall regime to observe that in as many as nine of the fifty years considered March registered a greater rainfall than April.

This touch of reality encourages a brief development of the idea on a graphical basis (Fig. 2). The crude ratios cannot be plotted on a compact diagram and have therefore been converted into what may be called "indices of differentiation." This is merely the difference between either side of the ratio and the point of equilibrium. Thus the ratio between March and April at North Platte, viz. 9 : 41, gives a differential index of 25–9 or 41–25, that is of 16. The length of the column plotted is thus a reflection of the rapidity of the change, or of the degree of differentiation between the months concerned. A

ratio of 25 : 25 gives an index of zero. Black columns indicate increasing precipitation, the month to the right having the majority; outline columns indicate decreasing precipitation, the month to the left having the majority. A horizontal line is drawn for each graph to indicate where a two-thirds majority is reached. It is with respect to this line that the columns should be studied. Below each diagram

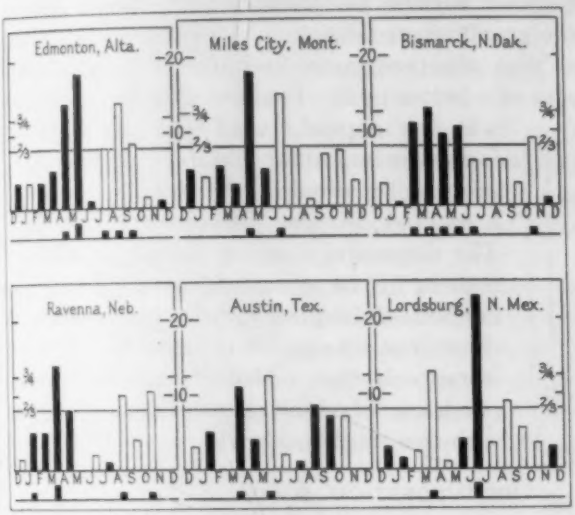


FIG. 2

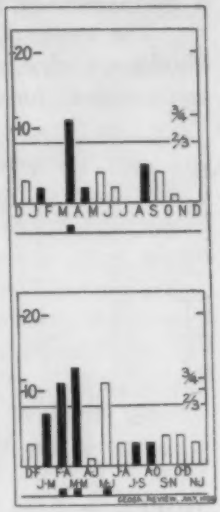


FIG. 3

FIG. 2—Comparison of differential indices and significant rainfall changes at six selected stations
FIG. 3—Differential indices for San Antonio, Tex., based on comparison of adjacent months (above) and alternate months (below).

is an index of the position of rainfall breaks as read from the dispersion chart, those of "major" dimensions being distinguished by a larger symbol. The degree of relationship between the two sets of results is thus evident from simple inspection. It must be remembered that the dispersion diagram, like the process of averaging, implicitly ignores the question of possible correlation between monthly values.[2] Theoretically there are grounds for expecting both direct and inverse correlation, and these would usually seem to neutralize each other. Frequency ratios ignore absolute amount of precipitation but are fully sensitive to any correlation that may exist, so that perfect correspondence in the results is unlikely.[3]

[2] Inverse correlation implies some degree of compensation, a surplus in one month being followed by a deficiency in another. Direct correlation implies that the two months move together, the whole season being relatively dry or wet as the case may be. It would seem that the latter type of variation is likely to give most trouble, especially in tropical regions. Its effect will be to make our test of significance a trifle too severe, but usually in regions where month-to-month contrasts are already striking. A compensating influence is likely to preponderate only where the regime is relatively uniform; hence our test becomes least exacting where month-to-month contrasts are weakest. A tendency to err on the side of severity would thus receive some justification.

[3] Further confirmation of the relationship will be found in H. A. Matthews: A New View of Some Familiar Indian Rainfalls, *Scottish Geogr. Mag.*, Vol. 52, 1936, pp. 84–97; and especially in the author's note on this paper, *ibid.*, Vol. 52, 1936, pp. 187–188.

Another aspect of our method is checked against frequency ratios in Figure 3. As San Antonio has a fairly even distribution of rainfall through the year, the columns in the upper of the graphs are short compared with those for Bismarck or Edmonton. If adjacent months are compared, only one significant change is recognized. A more complete view of regime may be obtained by supplementing this by a comparison of alternate months, i.e. January with March, and so on. The lower of the graphs gives the results of a count on this basis. Significant changes thus observed have been called "graded discontinuities" for want of a better term. Features already recognized will now appear spread over two columns, but other important and more gradual changes may be revealed. In this case we notice a marked decrease between May and July. The dispersion diagram permits any pair of months to be compared at a glance; the method of frequency ratios involves a new count, but its support is valuable. Another instance is thus added of the close correspondence of significant breaks or changes with two-thirds majorities.

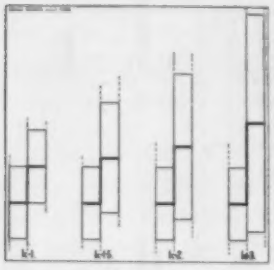


FIG. 4

THE THEORETICAL BASIS

The theoretical basis of our claim is necessarily somewhat tentative. It is assumed that there is no correlation and that distributions tend to approach the normal curve of error.

Let the difference between the means be d, standard deviations of means σ and $k\sigma$, and length of record n years.

Then standard deviation of $d = \sqrt{\frac{\sigma^2 + k^2\sigma^2}{n}} = \sigma\sqrt{\frac{1 + k^2}{n}}$.

But in a normal curve $\sigma = 1.482q$ where q is the quartile deviation, and in the present case the mean length of the record is 40 years.

Hence standard deviation of $d = 1.482q\sqrt{\frac{1 + k^2}{40}} = 0.234q\sqrt{1 + k^2}$. Now d is regarded as significant when it is greater than three times its own standard deviation, i.e. when $d > 0.7q\sqrt{1 + k^2}$; but if the scattering of the two sets of monthly values is roughly the same, k approaches unity, and we have $d > \frac{7\sqrt{2}}{10}q$ or $> q$: i.e. differences between means acquire significance when they exceed the distance from the quartile to the mean.

This relationship may be amplified by substituting other values for k, and the results are best expressed in graphical form. Figure 4 shows relative positions of medians and quartiles at which differences become significant when the scattering of the two sets of monthly values is very different. Clearly a little latitude is sometimes necessary in the application of our general rule, but extreme cases like these

are rarely encountered in practice. The dispersion diagram is only a rough guide, but even the most refined methods do not eliminate doubtful instances.

The Regional Distribution of Rainfall Discontinuities

Can it be demonstrated that these rainfall features have a definite and coherent space distribution? If so, it should not merely confirm their reality; it should also yield insight into their mechanism and implications. The challenge is answered in the dispersion chart and the summary maps that follow (Figs. 6 to 9). The difficulty of defining geographical limits must necessarily arise, but some vagueness along the borders is not incompatible with a definite distribution.

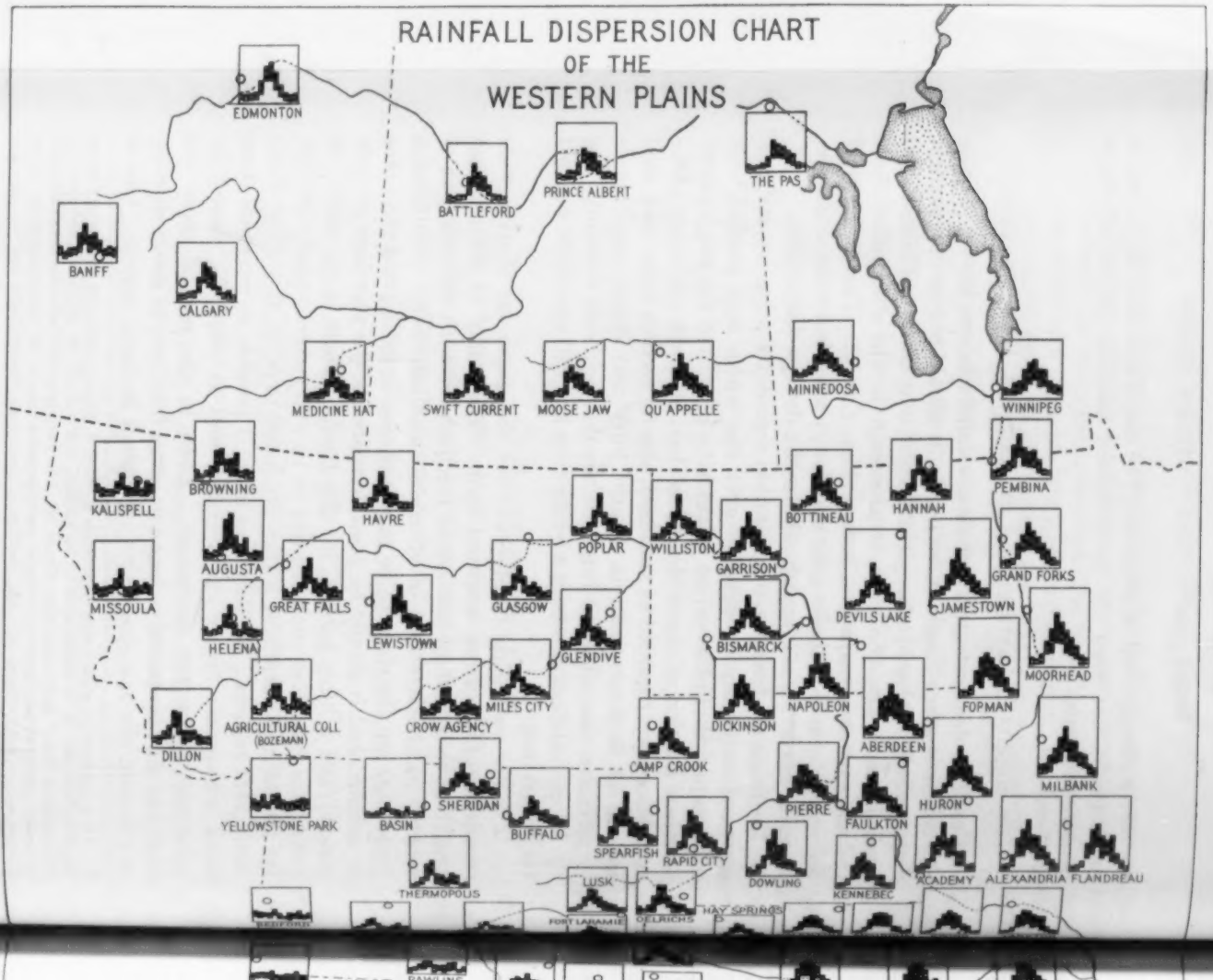
The maps are based on precipitation records for some 200 stations, scattered as evenly as possible over the whole area studied.[4] A uniform period of observation would have permitted the employment of only a fraction of the evidence, so that, although the years 1881–1930 have been regarded as standard, shorter records have been used as long as they terminate in 1930.[5] Fifty and thirty-year records give results that dovetail into one another without difficulty, but the full-period diagrams have a better trim and will usually be selected for illustration.

It is not surprising to observe over the dispersion chart a wide repetition of the same essential form. The study of normals has taught us to regard an increase of precipitation with the approach of summer as characteristic of all continental interiors. Two rainfall transitions are therefore to be expected, one in spring and the other in autumn, and it should be possible to divide the year into a "rain period" and a "dry period" on this basis.[6] There is no reason, of course, for expecting such changes to be everywhere equally abrupt, nor should it be surprising if they are found to occur at varying dates in different regions. The diagrams make it possible to recognize these dates with some degree of precision, and at once the superficial uniformity of aspect disappears. Even in the central areas the length of the rain period is found to range from two to seven months, and toward the margins many anomalous features appear. One is

[4] It is a pleasure to acknowledge the kindness of Mr. J. B. Kincer, chief of the Division of Climate and Crop Weather, U. S. Department of Agriculture, who supplied the sectional "Summaries of Climatological Data" used in this work; also of Mr. John Patterson, director, Meteorological Service of Canada, who provided manuscript tables of precipitation for some of the Canadian stations. H. H. Clayton, edit.: World Weather Records, *Smithsonian Misc. Colls.*, Vol. 79, 1927, and Vol. 90, 1934, and *Canada Year Book, 1931*, were also used.

[5] Of the 200 stations used 66 had records of 45–50 years inclusive, 98 had records of 35–44 years, and 36 stations with less than 35 years were used where no better information was obtainable. Thirty of these east of the 97th meridian have no representatives in the dispersion chart and were used mainly to improve the general setting.

[6] These terms will be used henceforth with this somewhat special connotation and in a purely relative manner. They form a logical development of the maximum-minimum idea from the new point of view.


RAINFALL DISPERSION CHART
OF THE
WESTERN PLAINS
EDMONTON
BATTLEFORD
PRINCE ALBERT
THE PAS
BANFF
CALGARY
MEDICINE HAT
SWIFT CURRENT
MOOSE JAW
QU'APPELLE
MINNEDOSA
WINNIPEG
KALISPELL
BROWNING
HAVRE
POPLAR
WILLISTON
BOTTINEAU
HANNAH
PEMBINA
AUGUSTA
GARRISON
GRAND FORKS
MISSOULA
GREAT FALLS
GLASGOW
DEVILS LAKE
JAMESTOWN
HELENA
LEWISTOWN
GLENDIVE
BISMARCK
MOORHEAD
AGRICULTURAL COLL (BOZEMAN)
MILES CITY
CROW AGENCY
NAPOLEON
FOPMAN
DILLON
DICKINSON
ABERDEEN
CAMP CROOK
MILBANK
YELLOWSTONE PARK
SHERIDAN
BASIN
BUFFALO
PIERRE
FAULKTON
HURON
SPEARFISH
RAPID CITY
DOWLING
KENNEBEC
ACADEMY
ALEXANDRIA
FLANDREAU
THERMOPOLIS
LUSK
FORT LARAMIE
DELRICHS
HAY SPRINGS

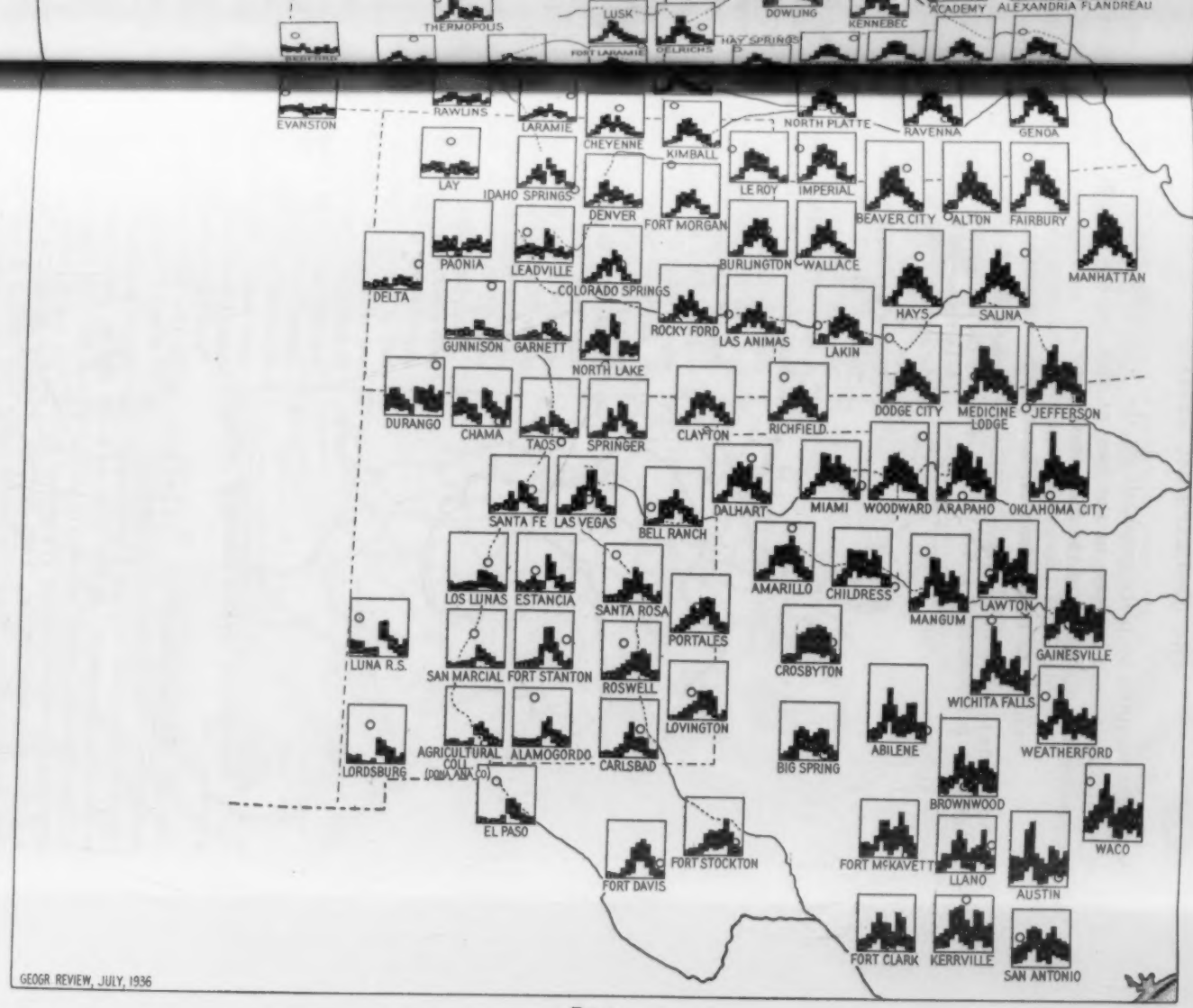

THERMOPOLIS
LUSK
DOWLING
KENNEBEC
ACADEMY
ALEXANDRIA
FLANDREAU
BASIN
FORT LARAMIE
GUERNSEY
HAY SPRINGS
EVANSTON
RAWLINS
LARAMIE
CHEYENNE
KIMBALL
NORTH PLATTE
RAVENNA
GENOA
LAY
IDAHO SPRINGS
DENVER
FORT MORGAN
LE ROY
IMPERIAL
BEAVER CITY
ALTON
FAIRBURY
PAONIA
LEADVILLE
BURLINGTON
WALLACE
MANHATTAN
DELTA
COLORADO SPRINGS
HAYS
SALINA
GUNNISON
GARNETT
ROCKY FORD
LAS ANIMAS
LAKIN
NORTH LAKE
DODGE CITY
MEDICINE LODGE
JEFFERSON
DURANGO
CHAMA
TAOS
SPRINGER
CLAYTON
RICHFIELD
SANTA FE
LAS VEGAS
BELL RANCH
DALHART
MIAMI
WOODWARD
ARAPAHO
OKLAHOMA CITY
LOS LUNAS
ESTANCIA
SANTA ROSA
AMARILLO
CHILDRESS
MANGUM
LAWTON
GAINESVILLE
LUNA R.S.
SAN MARCIAL
FORT STANTON
PORTALES
ROSWELL
CROSBYTON
WICHITA FALLS
LOVINGTON
ABILENE
WEATHERFORD
AGRICULTURAL COLL.
ALAMOGORDO
CARLSBAD
BIG SPRING
LORDSBURG
(DONA ANA CO.)
BROWNWOOD
EL PASO
WACO
FORT STOCKTON
FORT McKAVETT
LLANO
AUSTIN
FORT DAVIS
FORT CLARK
KERRVILLE
SAN ANTONIO
GEOGR REVIEW, JULY, 1936

FIG. 5

no longer tempted to place emphasis on the widespread occurrence of maximum values in June in the face of this marked variation. We proceed to an analysis of the discontinuities.

Analysis of Discontinuities: Significant Increases

An attempt to delimit the areas showing significant increases at different periods has been made in Figures 6 and 7. For the sake of brevity the changes are referred to by the name of the month during which the increase first becomes conspicuous. Thus a significant increase between March and April is called the "increase in April." The material at hand makes any further degree of accuracy impossible, but it is doubtful whether climatic changes over most of the earth's surface will ever be found to move within narrower limits.[7] The months of rainfall increase are therefore March, April, May, June, July, and September, but it is clear at a glance that these are by no means of equal scope and validity.

Fig. 6—Areas exhibiting significant increases of precipitation in March and July.

July and September are both anomalous in the sense that they fall in the second half of the year, but they are otherwise of unequal importance. The September increase could be almost ignored on the ground that it is found only in local marginal areas in western Montana (Helena) and southern Texas (Austin) and is rarely more than doubtful in magnitude. The July break, on the other hand, involves the most marked change in precipitation conditions in the whole region. Recognizable in the central and southern Rockies, it becomes particularly abrupt in the southwest after six almost rainless months. As July is also the month with maximum median values in much of this area, a rapid accession of conditions favorable to precipitation would seem to be followed immediately by a gradual decline. The east border of the region is of more than usual interest. From southern Wyoming the line runs southward along the Rocky Mountain foothills, leaving Longs Peak (station at 8956 feet) and Idaho Springs (7543) on the one hand and Fort Collins (4985) and Denver (5283) on the other, till it reaches an area where the prairie surface itself exceeds 6000 feet. It

[7] Where changes are unusually rapid, as in monsoon and Mediterranean areas, a plea might be entered for summary on a fortnightly basis. It is unlikely that weekly figures would be of value, since their mean variability will tend to be twice ($\sqrt{4}$) that of monthly data, already large.

then swings out from the mountains to include Castle Rock (6201) and continues southward again at a mean distance of some 70 to 80 miles from the foothills till it borders the Pecos Valley along the flank of the Guadalupe Mountains. The relationship with elevation along this border is strengthened by the fact that in the same latitudes the change is more abrupt in the higher station. The practical importance of the beginning of the rain period at so late a date must be considerable. Fluctuation of the east border may prove to be a key to drought incidence.

Of the four remaining normal increases, two may be regarded as dominant and two as supplementary. The supplementary increases occur in March and June and usually form part of a series. The March feature gives an irregular outline free from that of April only in the extreme east. The absolute increase of precipitation involved is rarely as much as 0.75 inch, even in Iowa and Missouri, where it is at its greatest. Irregular tongues extend southward over the Ozarks and westward as far as Wyoming. A small outlying area in Colorado has not been shown. The June break is almost entirely confined to Canada, where the network of stations is less complete and limits cannot be indicated with the same confidence. In the west the increase merely supplements an initial rise in May; but in the northeast, where Prince Albert and The Pas alone have long-period statistics, it takes on dominant characteristics and is almost a major discontinuity.[8] It is this increasing part played by June as the effective beginning of the rain period that underlies the distinction between zones with June and July maxima on the map by A. J. Connor in the *Canada Year Book* for 1926. Later rains and earlier winters provide the "combination with very poor agricultural possibilities" referred to (p. 45).

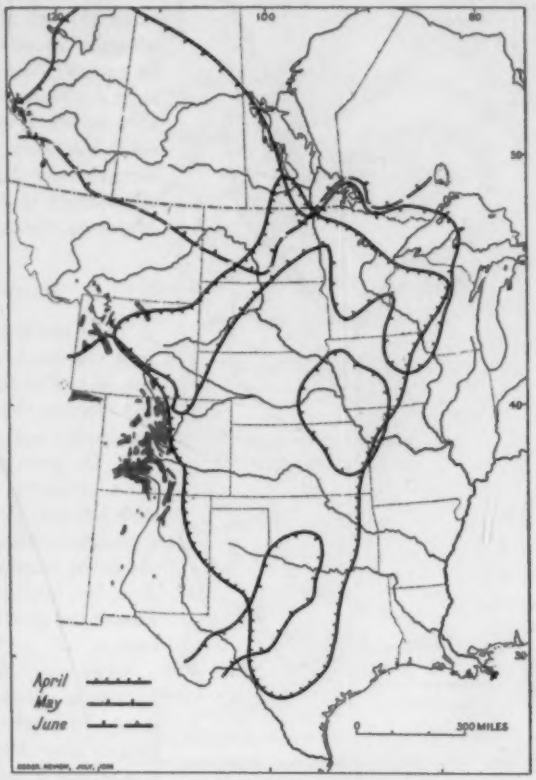


FIG. 7—Areas exhibiting significant increases of precipitation in April, May, and June.

We are thus left with the significant increases in April and May, which are regarded as dominant, not only because they are widely experienced, but because the change is usually abrupt and the summer rains are ushered in without further transition. Within these two months the rains would seem to sweep in toward the Canadian parkland belt at a mean speed of about 25 miles a day. However fantastic such a calculation appears, it will at least serve to remind us that the features we are analyzing are essentially dynamic. The main areas involved in each case are relatively simple in outline, and the degree of overlap in the Dakotas and Wyoming

[8] When there is no overlap between adjacent quartile ranges. See Crowe, *op. cit.*, p. 80.

is inconsiderable. Toward the center of each region the changes reach nearly major dimensions. The April feature is almost entirely confined to the plains and is particularly developed in the eastern Dakotas, central Nebraska, and western Kansas. April is here almost as rainy as any of the following summer months, and the conception of a rain period finds full justification. The May feature extends into the Rockies but reaches its greatest amplitude in Montana and western Canada. The north border must of necessity be somewhat tentative, but in the south the limit is an almost straight line from Greeley, Colo., to Grand Forks, N. Dak. Beyond the 97th meridian this simplicity is lost, and a series of irregular areas, extending from Lake Superior to central Texas, appears in the diagram. It is as if a second "wave" of precipitation were able to break over this region but failed to reach the west. Yet, although the absolute increase from April to May is often striking, the relative supremacy of the initial rise from March to April usually remains unchallenged.

FIG. 8—Areas experiencing significant decreases of precipitation in June, July, and September.

SIGNIFICANT DECREASES

The months of rainfall decrease are June, July, September, October, and November, but, in the United States at least, the June and October features are only local and the dominant changes come at two-month intervals. The cessation of the rains is thus effected in an altogether more deliberate fashion than their advance, but it is a hesitant rather than a continuous decline. No very obvious explanation of this contrast seems to be available, but its importance is considerable in view of the variety of rain periods that follows from it.

The anomalous feature of a decrease in June is confined to the high basins of Wyoming and western Colorado. As far as can be judged from the scanty information available, it does not include the really lofty areas but is, so to speak, wrapped around them. A narrow tongue extends southeast as far as Denver and produces interesting contrasts between its regime and that of Colorado Springs, not more than 60 miles away. Low precipitation values in June are common to both stations, but greatest median values occur in May in Denver and in July in Colorado Springs. The June decrease at Denver is like the July increase seen in a mirror, but it is a weaker feature and nowhere reaches major dimensions.

The decrease in July certainly falls in the second half of the year but is unexpectedly early nevertheless. As illustrated in Figure 8 it forms a dominant feature over a great wedge of country extending from the Black Hills to the Canadian border and reaches almost major dimensions in the zone between Miles City and Williston. The practical importance of a marked fall in precipitation values at such a time, particularly in a region where the annual total is usually far from generous, should not require emphasis. Obvious contrasts in the regimes of the Prairie Provinces and Montana now become evident, and the border of this feature will have to play an important part in any regional subdivision of our area.

With the arrival of September we reach the period when the autumnal decline in rainfall values is only to be expected. The feature provides one of our most striking outlines, the area involved being nearly 2000 miles long and in many places 250 miles wide. It lies on both sides of the area that suffered loss in July, and the borders lose their definiteness only where it overlaps that region in the east. In fact, the valley of the Red River provides the only region where our method meets with really serious difficulty. The rains seem to decrease with remarkable steadiness over a long series of months, and no outstanding breaks can be recognized. At the outset this might have been regarded as the normal course of events, but the relative rarity of this type of change indicates that it is due to the blurring of regime in a transitional location. This view finds support in the existence of occasional stations showing the September feature as far east as Minnesota, and the border has been given by a broken line to include them. The western limits are also of interest. Clearly a decrease in September is precisely the opposite of what would be expected of rains that had their origin in the Pacific. Notice then that the north borders lie clear of the mountains; but in the south, where the Cordillera is so much broader, stations as high as Idaho Springs and North Lake and as far west as Leadville and Alamogordo show the feature clearly.

FIG. 9—Areas experiencing significant decreases of precipitation in October and November.

The October break is mainly a Canadian feature. On the plains it is usually no more than supplementary to the more marked change in September, but toward the limits of our study in the north there are indications that it becomes dominant. The rain period is thus delayed until June to September inclusive. There are two outlying areas in the United States, the more important being found in the basin of the upper Mississippi. The most interesting stations lie between that river and Lake Michigan, and the relation between the outline and the lake shore is suggestive.

Finally, the November break gives us another compact outline closely comparable in its general distribution with that for April. Over the greater part of the west-central states, therefore, the dry period of winter includes four or five months during which there are no further appreciable variations in precipitation conditions. Winter stability is in marked contrast with the variety of summer regimes. Whereas the western limits of this feature would provide yet another index of relative freedom from Pacific influences, the eastern borders will enable us to delimit that portion of the continent with a rainfall regime that has none of the usual continental characteristics.

Rainfall Provinces

The chief discontinuities described above clearly fall into four categories. The decrease in June and the increase in July are both closely associated with the central and southern Rockies and seem to suggest an eastward migration of influences from the western plateaus. The element of relief is uppermost.

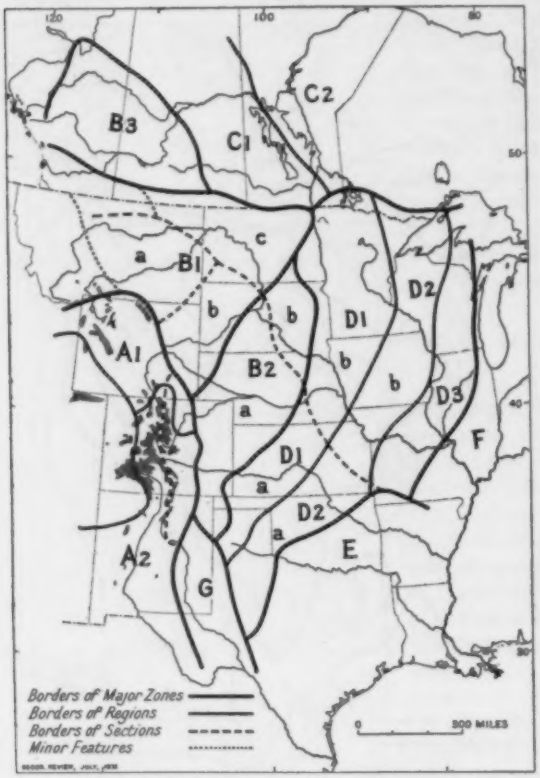


FIG. 10—Rainfall provinces of the Western Plains.

The increase in April and the decrease in November cover much common territory in the west-central states and seem to reflect a nice balance between forces based on both latitude and longitude.

The increases in May and June and the decrease in October are of Canadian interest particularly, and a general distribution in latitude suggests that the temperature factor is dominant.

The decreases in July and September give characteristically wedge-shaped or triangular forms with a base along the mountain front. The influence of latitude or longitude is thus negligible, and continentality, or distance from Hudson Bay or the Gulf of Mexico, seems to come into play. Lander, Wyo., is about equidistant from Corpus Christi and Port Nelson (ca. 1250 miles).

These sets of contrasting distributions offer a logical key to the delineation of rainfall provinces. The purely mechanical process of superimposing Figures 6 to 9 must give a first approximation on the basis of the chief events in the rainfall cycle. The division scarcely becomes geographical, however, unless some degree of selection and interpretation is applied to this raw material. This will supply an opportunity of considering minor features such as secondary rain periods and more gradual changes. Figure 10 is the result of such a process. The chief divisions, classified as zones, regions, and sections in descending order of magnitude, are described below.

The Rocky Mountain Zone (A)

This is easily delimited by using the margins of areas experiencing the mid-summer rainfall changes that can be expressed stenographically as "June −" and "July +." The very real minimum in June is common to the whole zone and has not previously been given adequate recognition. Yet no one would deny that a marked reduction in precipitation at the height of summer must of necessity bring important consequences in its train. If the feature is a distant echo of the summer drought of the Pacific coast, it is remarkable that it is confined to a single month. The suggested relation with elevation is rather subtle and can be tested only by careful observation in the field.

A transverse division of this zone into two regions is possible according to which of the two ratios—May : June and July : June—preponderates. These two regions are divided longitudinally according to the degree of transition from plateau to plains regime. The westernmost sections might very well be regarded as composing part of a new Great Basin Zone, lying entirely beyond our province. The real minimum in June remains, but it is the only significant event in an otherwise remarkably even distribution through the year. None of the really characteristic features of the plains regime, e.g. "April +," "September −," "November −," extend so far west (see Lay and Durango, Colo.).

1. The *Laramie Region* is the northern area, where the bulk of the year's rain falls before the month of June. The diagrams suggest that the conception of a May maximum in this region is not entirely unreasonable, but there is no justification for regarding this as implying an earlier arrival of the rains: they merely end earlier. The June break is thus the significant feature. The rainfall year may be divided broadly into three periods by the breaks in April, June, and November. The primary rain period of April-May (locally March-April-May) is followed by five months during which more than an inch a month is rarely recorded. This forms a weakly developed secondary rain period as compared with the very low records of mid-winter. Such a threefold division represents the limit of our precision, and the alleged secondary maximum in October is not confirmed. Only at Lander, where October has significantly more rain than August (a graded change), is there any sound basis for such an assertion. In any case, the records are too fragmentary for a confident conclusion.

An eastern section of this region must be distinguished where higher mean annual totals seem to be the result of a modification of the secondary rain period just described. Precipitation is better sustained during the months June-July-August, so that these are divided from September-October, either by a sharp discontinuity, as at Denver, or, more usually, by a graded change between July and September. The rainfall year thus falls into four seasons instead of three.

2. The *Rio Grande Region* falls into similar eastern and western sections, but the primary rain period of July-August is common to both, and in "Summaries of Climatological Data" a correlation with thunderstorm frequency is suggested. In the western section precipitation conditions remain practically unchanged during the first half of the year. The "April +" feature of the southern plains is no longer in evidence, and toward Lordsburg and Luna an actual decrease at that period becomes apparent. The rainfall year thus falls into a short rain period and a long dry period. If subdivision is required, it must be based on absolute amount. A southern subsection can be distinguished where the lower quartiles of the first six months are very near zero.

In the eastern section a secondary rain period from April to June is developed. It would seem to be fellow to the June to August period of the eastern section of the Laramie Region. In both sections a rain period of two months is supplemented by three months of scantier precipitation, an approximation to the five-month rain period of the neighboring plains being thus indicated. Nevertheless, the hallmarks of the Rocky Mountain Zone are not obscured until the foothills are left about a hundred miles to the rear.

The Upland Plains Zone (B)

This name will be used to designate the central core of our province as distinguished from the lowlands to the east. It must be defined on the basis of features peculiar to the plains proper and thus covers the areas of the "July −" and the "September −" changes. Its chief characteristic is the relatively early decrease in rainfall in the autumn. The eastern limit of the zone is drawn along the border of the significant change in September; but even if the more gradual change from August to October had been employed instead (see below), the limit would only be shifted eastward some 125 miles, and the essential wedgelike form would be retained. This is of interest in view of the similar shape of the broad mass of natural grassland.

Three chief regions are distinguishable on the basis of sharp discontinuities, but an element of overlap is introduced as soon as graded changes are considered. Transitions from one regime to another must obviously be effected in a gradual manner, and beyond the normal limit of any sharp discontinuity its influence may be reflected in a graded change that cannot be ignored. The relative weight to be attached to simple and graded discontinuities must be left to emerge from practical experience. In the meantime graded discontinuities will be regarded as of secondary importance only.

1. The *Upper Missouri Region* has a primary rain period of only two months, May and June. The relative poverty of Montana records makes detailed analysis difficult, but the region would seem to be the least favored part of the whole Plains Zone. Division is possible into a central section, where characteristics are clearly developed, and a transitional fringe of some complexity.

Miles City and Helena illustrate the central regime, with only two sharp breaks, in May and July, defining the rain period from ten drier months that at first seem featureless. Closer inspection reveals graded changes between February and April and between September and November. These represent the weakened influence of the "April +" and "November −" features, whose limits as sharp changes lie to the south. Transitional or secondary rain periods are thus recognizable, but the monthly precipitation is only slightly greater than that during the winter dry period and decreases steadily toward the west.

The changes toward the fringe of this region represent a general tendency to iron out the abruptness of the May and July features by spreading the increase or decrease over a longer period of time. After June this is effected in all directions by a steady increase in the precipitation of the secondary rain period, particularly of July. The July break is thus reduced in intensity and graded changes between July-September and August-October appear, heralding the approach of an ultimate "September −." Before June the variations are rather more complex and justify a division into two subsections. In the south the same "filling in" process seems to be in operation, and March and April values rise till the May increase appears much less abrupt. May still retains its position, however, and is often the month with the highest median value (see Lusk, Wyo., and Rapid City, S. Dak.). In the north, on the other hand, May values are reduced till they are often no larger than those for July. Here, then, a "June maximum" is at length a reality, since there is in fact a single maximum month. At Bismarck the whole period from March to October inclusive is one of continuous change in rainfall intensity. Only the four winter months show any real stability.

2. In the *Platte Region* proper, although June still records the highest median values, not even April or August can be expected to receive much less. A definite rain period of five months may be regarded as established. In addition a secondary period including September and October is marked off by the "November −" feature. The winter drought is thus rarely more than four months long, March being transitional and not easily classified. A minor feature in winter is the persistence with which January tends to assert itself as a definite minimum with significantly less precipitation than its neighbors. Although the contrast is only of the order of 0.2

inch in January as compared with 0.4–0.5 inch during the other winter months and is probably of no conceivable practical importance, it must reflect some definite meteorological influence (see Wallace, Kan., and Burlington, Colo.).

Beyond the Missouri River it has been necessary to distinguish the northern section of this region on the ground that virtual equality of the five rain-period months no longer exists. Graded changes between April and June or between June and August (or both) become persistent, so that again there is an echo of the old conception of a June maximum. It may be well to anticipate matters a little at this point and draw attention to the fact that, throughout its course, sectional boundaries run roughly parallel to the Missouri. It may be asserted that to the south and west of that line the new method completely kills the idea of June predominance, to the northeast it provides a strictly qualified confirmation.

3. The *Upper Saskatchewan Region* is the Canadian equivalent of the above but can be discussed only tentatively owing to its relative poverty of long records. At Calgary the chief features are clear enough, and sharp breaks in May and September define a rain period of four months. It is true that uniformity of precipitation is nowhere else attained during the rain period, but even where contrasts between the four months are most marked, as at Edmonton, there is no difficulty in distinguishing them from the seven months of winter drought. September is the only month that can be in any way termed transitional.

The Central Canadian Zone (C)

This forms a broad area toward the northeast lying almost entirely within the provinces of the "June +" and "October –" features. We have already encountered the difficulties inherent in fragmentary records, but there is some justification for a twofold division.

1. The *Athabaska-Assiniboine Region* lies to the west where summer rains are ushered in by successive breaks in May and June and decline somewhat gradually thereafter.

2. The *Nelson Region* has a much more clear-cut rain period from June to September inclusive, the rest of the year being a period of apparent stability. In view of the short records on which this generalization is founded, it was thought unwise to include the diagrams on the chart. It must be regarded as provisional.

In the extreme south Winnipeg and Kenora give an anomalous "August –" break, but its relationships are obscure.

The West-Central Lowland Zone (D)

It is possible to speak with much greater confidence regarding the remaining area south of the immediate neighborhood of the international boundary. Broadly the predominant rain period throughout includes the seven months from April to October inclusive. Nevertheless, it would be very surprising indeed to find strict uniformity over an area extending from Minnesota to Texas and from the Red River to Lake Michigan.

The best basis for division will be the existence of graded changes during the long rain period. Three parallel belts thus emerge. In view of the fact that they lie athwart the main lines of drainage, the policy of giving them river-basin names[9] is more difficult to apply, but it will be adhered to for the sake of uniformity.

1. The *Arkansas–Red River Region* forms a belt about 125 miles in width along the east margin of the Upland Plains Zone. It is the area where there is still a significant change between August and October, though the contrast between August

[9] In view of the relation between river and rainfall regime. Even the relative vagueness of these names is perhaps an advantage, since each of our regions consists of a central core with recognizable features shading off gradually into its neighbors in all directions.

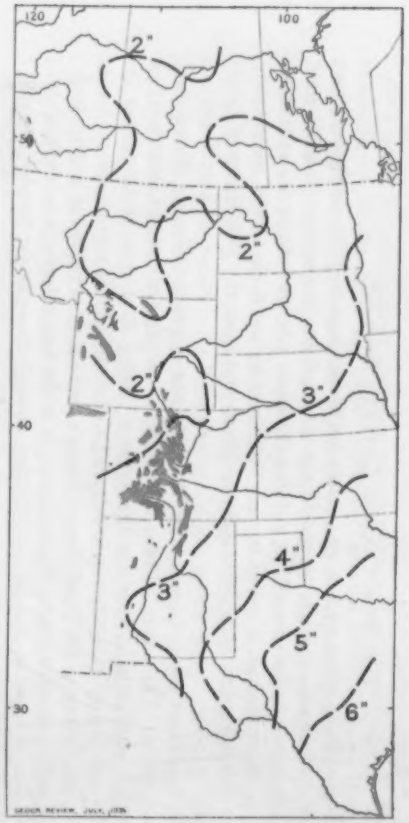


FIG. 11

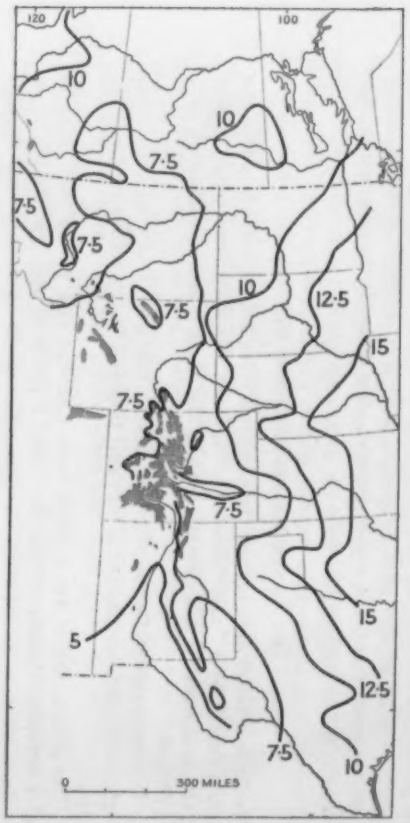


FIG. 12

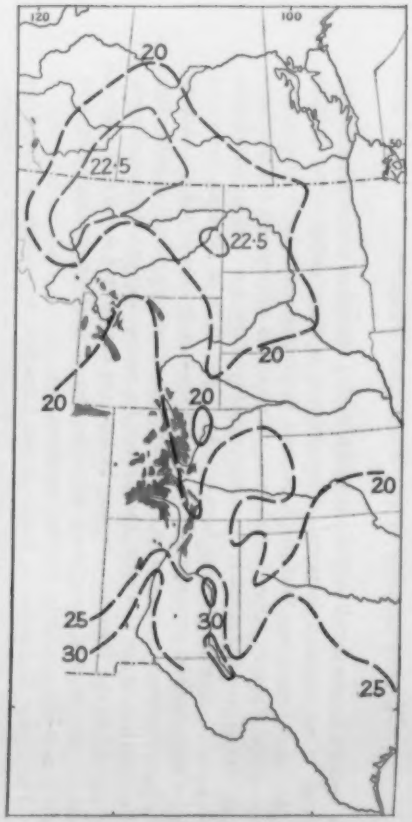


FIG. 13

FIG. 11—Difference in inches between mean annual total rainfall and sum of monthly medians. The map is much generalized, but a prevailing excess of 5 to 6 inches in Texas may help to explain why crop limits tend to run diagonally across isohyets (compare *Scottish Geogr. Mag.*, Vol. 49, 1933, p. 85).

FIG. 12—Sum of medians (in inches) during the five months April to August inclusive.

FIG. 13—Sum of medians (in inches) during the six months April to September inclusive.

and September is slight enough to be negligible. If the limit of the "September −" feature is regarded as giving a minimum interpretation of the sphere of Plains regime, the eastern limit of this belt should provide a border beyond which it can be in no way considered to extend. Where at least seven spring-to-autumn months show no significant rainfall variation, the midsummer concentration of the Plains regime must surely be regarded as no longer achieved.

As in the Platte Region, the northern section of this belt must be distinguished on the ground that further graded changes are recognizable during the rain period. The most persistent is an increase from April to June, becoming abrupt enough locally to appear as a sharp break in May. Contrast between June and August is less universal.

2. The *Canadian River–Des Moines Region*. In this belt the August-to-October break disappears, with the result that in the southern section there is no significant change during the seven rainy months. At least, significant contrasts appear only when columns three months or more distant from one another are compared, and such instances are isolated and make generalization impossible. We have now only to place the diagrams for Miles City, North Platte, and Crosbyton side by side to see the "Missouri Type" with its alleged June maximum in its true colors. The conception of three distinct regimes with rain periods of two, five, and seven months is clearly much nearer the facts.

The northern section experiences a little greater variety, particularly between April and June; but it is remarkable that even as far north as Duluth there is virtually no contrast in the precipitation recorded in any of the six summer months, May to October.

3. The *Illinois River Region* borders this last section on the east and is closely comparable with it. It lies beyond the provinces of the "April +" and "November −" features, but these are merely anticipated by similar breaks in March and October. There is again a remarkable uniformity during the rain period except for a graded change between March and May. This is only to be expected when it is remembered that the "April +" and "May +" borders are not far to the west.

The Gulf Zone (E)

This forms part of the eastern borders of our province and as such must not detain us except in so far as it throws light on the nature of transitions. It is a region of great rainfall variability (see Fig. 13) and irregularity of regime. The April and November features of the north weaken southward, and a significant increase in May appears but is not sustained. Only one factor is common to the whole group of stations—the graded change between May and July. It is as if the tendency toward a regular annual rhythm was becoming so weak as to make a longer time span necessary. Regime is, in fact, ceasing to exist, and neighboring diagrams differ to a remarkable degree. The conception of double maxima in May and September finds little confirmation in the facts.

The East-Central Lowlands (F)

These too must await future analysis, but the characteristics of such border stations as have been encountered may be mentioned. Sharp breaks cease to exist, and the only graded break that is at all common occurs between February and April. The rainfall cycle thus shows a little variation early in spring, but the rest of the year is a period of almost imperceptible change.

Overlapping Zones (G)

We have already recognized that overlap must occur and can cite the case of the Arkansas–Red River Region as a good example of an easy transition. Between

zones A, B, and D the contrasts are much more striking. A narrow belt with special conditions should be recognizable between the west, with its low June values, and the east, where that month often has the greatest mean rainfall expectation.

As far as the borders of A and B are concerned, there is little evidence to justify any further subdivision. It is true that the diagrams for Helena, Sheridan, Lusk, and Las Animas have the special feature of relatively low June values as compared with stations more distant from the mountains. Fluctuation of the east margin of the Rocky Mountain Zone would tend to produce this form, but the invasions are not frequent enough to confirm a significant change.

In the south, however, the contrasts between zones A and D are extreme. A region with practically no rainfall in the first six months of the year is brought into direct contact with another receiving at least half of its total during that period. A series of easily recognizable transition stations can thus be perceived, and the area has been called the *Pecos Region*. Characteristic features are the absence or weakness of the "April +" or "November −" changes so widespread in the east and the substitution of graded changes in April-June and May-July for the clear "July +" of the west. Lower quartiles in the early part of the year suggest that spring drought is by no means unknown and that this area is one where no type of mean will give a true interpretation of the facts. This is true of any region where two regimes may be experienced alternatively. In such cases there are clearly two normal annual cycles, not one, and analysis must be by a specially designed technique (see Roswell, N. Mex.). The rainfall-year concept is the only possible one.

Conclusion

Such are the results of an objective study of precipitation on a purely relative basis. The work has been a logical continuation of the process of observation that had its origin when Weather Bureau agents read their gauges. The statistical material has been allowed to yield its own results, and in a very real sense the discussion might be summed up as "Rainfall Relativity." Precision has been given to the conception of a Plains type of rainfall, and it has been saved from a uniformity that was chaos.

Yet absolute precipitation values have their importance, and relative regime is not everything in a truly geographical study. The maps, Figures 11–13 (p. 482), are included as brief comments on other aspects directly derived from the method that has just been analyzed.

A ROTARY WIND CURRENT OFF THE FLORIDA COAST

F. J. Haight
U. S. Coast and Geodetic Survey

CURRENTS in the open sea, particularly those in the areas adjacent to the continental coasts, are exceedingly complex in character. Numerous forces, astronomical and meteorological, are reflected in these ceaseless and ever varying horizontal movements of the water. Tidal currents, into which are woven all the periodic gravitational pulls resulting from the changing relative positions of sun, moon, and earth, combine with wind currents, erratic or continuous, and with the permanent drifts of large masses of water known as ocean currents. Currents also result from the discharge of rivers into the sea, from the melting of ice, unequal precipitation, barometric changes, and other causes.

A rotary wind current at St. Johns Lightship, off the mouth of the St. Johns River, Florida, has been revealed through an analysis of current observations, and it is shown that the wind that sets up this current is itself rotary.[1] The observations on which the evidence of this cyclic wind current is founded were begun in December, 1933, and were continued through the entire calendar year 1934.[2] Measurements of the velocity and direction of the current were taken and recorded at the beginning of every hour. The velocity and direction of the current were determined by means of a 15-foot wooden current pole so weighted at one end that it floated vertically with 14 feet of its length submerged. Attached to the pole was a light line so marked that, by allowing the pole to drift for a given period of time, the velocity could be read directly from the line in nautical miles an hour or in knots. To determine the direction of the current, the direction of the ship's head and also the angle that the current line made with the fore-and-aft line of the ship were noted and recorded. These two values properly combined gave the direction of each observed velocity. At the time of each current observation the direction and estimated velocity of the wind were entered in the record.

The current as recorded shows little evidence of any consistent trend, periodic or otherwise, the velocities differing erratically in both magnitude and direction. Current velocities of more than one knot occurred infrequently and when recorded were usually accompanied by winds of 20 to 40 miles an hour.

A Relatively Large Solar Constituent

The separation of the constituent currents of the complicated movement is possible only by painstaking analyses of carefully obtained observations covering a long period of time. The processes used are somewhat involved and for the present purpose will not be described in detail. It may be well to mention, however, that for such weak and irregular offshore movements as that of the current at St. Johns Lightship a necessary preliminary step is the resolving of every observed velocity into two components at right angles to each other. It is obvious that combining or averaging directly velocities in all directions would give meaningless results. After the resolutions have been made, however, the component velocities may be subjected separately to any grouping or mathematical process desired. From the resulting components the resultant velocities and directions are obtained.

[1] The term "wind current" as used in this article refers to the horizontal movement of the water produced by the action of the wind.

[2] Much credit is due the master of the lightship, Captain H. T. Brett, and the members of his crew for their wholehearted coöperation in obtaining the excellent observations.

To separate and evaluate the more important constituents of the tidal current, the hourly velocities for 369 days were analyzed harmonically,[3] separate analyses being made for the two components. The results of these analyses were surprising in that the magnitude of the diurnal solar constituent S_1,[4] the period of which is exactly a calendar day, was unusually large relative to the other constituents ob-

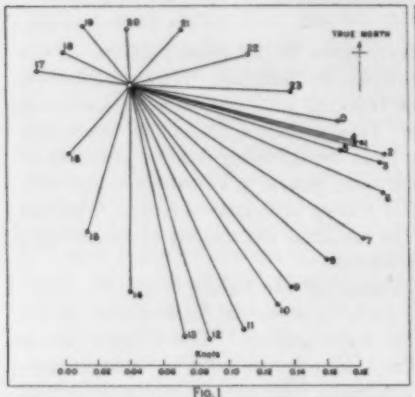


FIG. 1

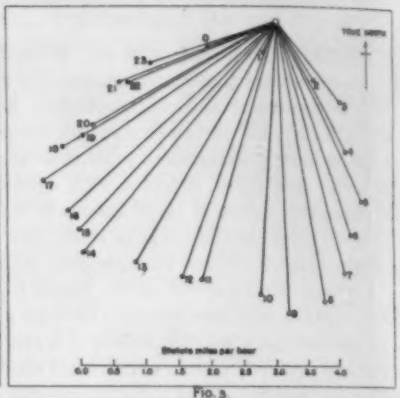


FIG. 3

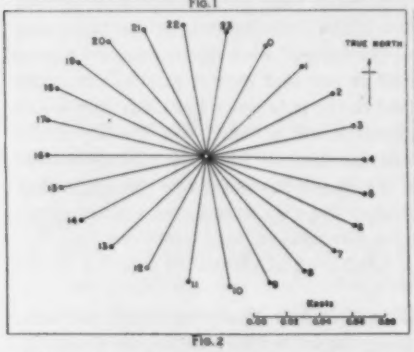


FIG. 2

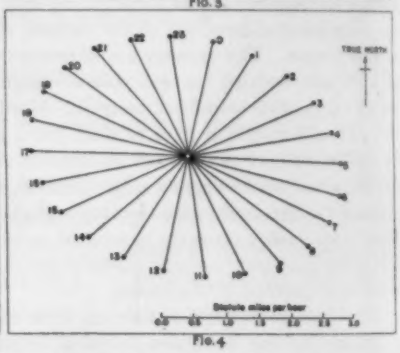


FIG. 4

FIG. 1—Average observed current at St. Johns Lightship for each hour of the day.

In this and the following figures the hourly velocities and direction of the movement portrayed are plotted from a common origin. The distance of each plotted point from the origin represents the velocity at the hour of the day indicated by the numeral, and its direction from the origin represents the direction toward which the current or wind is setting at that hour.

FIG. 2—Current ellipse from analysis of values represented in Figure 1.

FIG. 3—Average observed wind at St. Johns Lightship for each hour of the day.

FIG. 4—Wind ellipse from analysis of values represented in Figure 3.

tained. Although in the tides of this area the magnitude of the S_1 element is only about 1 or 2 per cent of that of the principal lunar semidiurnal element M_2, the current results for St. Johns Lightship show the magnitude of the S_1 element to be 56 per cent of that of the M_2 element. There thus exists at this location an S_1 current that has an average velocity at strength more than half as great as that of the M_2 current, which is the preponderant tidal current along our entire Atlantic coast.

[3] For details of this process as applied to tidal movements see Paul Schureman: A Manual of the Harmonic Analysis and Prediction of Tides, *U. S. Coast and Geodetic Survey Special Publ. No. 98*, 1924.

[4] For a study of the daily, or S_1, current an entire year of continuous observations is necessary. If a shorter group is used, the effects of certain tidal constituents having periods approximating closely the S_1 period will remain in the results. The lunisolar diurnal constituent K_1 is the chief offender in this respect owing to its rather large magnitude coupled with a period only about one-fourth of one per cent shorter than the period of S_1.

Correlating Current with Wind

The existence of such a periodic current with practically no corresponding rise and fall of the tide implies a cause other than that usually associated with tidal movements. The idea that a land-and-sea breeze might be the cause suggested itself, and the results of an investigation along this line are shown graphically in Figures 1 to 4 inclusive.

Figure 1 shows the average observed current for each hour of the day as derived from 369 days of observations. Each plotted point represents the resultant current for its particular hour. As each hourly value is the average of a large number of observed values, accidental effects as well as cyclic movements having periods other than the solar period are for the most part eliminated. There remains, however, an average nonperiodic, or permanent, flow of 0.086 knot setting S 51° E. It includes such effects as those produced by drainage, prevailing winds, and ocean currents.

Figure 2 shows the values of Figure 1 as separated from the permanent flow and smoothed by harmonic analysis. Figures 3 and 4 show values derived from the wind observations that were made at the lightship in connection with the current measurements. The observations cover exactly the same period of time and were subjected to the same reduction processes as the currents represented in Figures 1 and 2. The nonperiodic wind included in the values of Figure 3 had a computed velocity of 2.69 statute miles an hour setting S 25° W.

Rotary Nature of the Movements

Figures 2 and 4 show striking similarity between the wind and the current movements. Both are rotary, changing direction progressively in a clockwise movement from hour to hour. The maximum velocities of each are in a direction about normal to the shore line, and the minimum velocities are in a direction about parallel to the shore line. The computed times, directions, and velocities of the maximum and minimum phases of the two movements are as follows:

	Maximum			Minimum		
	Time	Direction	Velocity	Time	Direction	Velocity
			Mi./hr.			*Mi./hr.*
Wind . . .	6.05 p. m.	N 76°.0 W	2.42	12.05 a. m.	N 14°.0 E	1.79
	6.05 a. m.	S 76°.0 E	2.42	12.05 p. m.	S 14°.0 W	1.79
			Knot			*Knot*
Current . .	5.25 p. m.	N 72°.6 W	0.100	11.25 p. m.	N 17°.4 E	0.077
	5.25 a. m.	S 72°.6 E	0.100	11.25 a. m.	S 17°.4 W	0.077

It appears that the daily, or S_1, constituent of the wind as shown in Figure 4 differs materially from the usual conception of a land-and-sea breeze. Instead of a breeze blowing landward during the daytime, slackening to a calm and then blowing seaward at night, there is a continuous breeze changing its direction always to the right at an average rate of 15° an hour. It is interesting to note that the direction of the breeze at its maximum velocity is about 25° to the right of a line drawn normal to the coast line. This deflection presumably is due to the earth's rotation.

It is to be noted that this S_1 breeze does not necessarily occur in the form described each day during the year. The values given represent an average daily condition for the 369-day period as derived from the recorded hourly velocities and directions. Any resultant effect such as an excess of sea breeze over land breeze is, from the nature of the reduction processes to which the observed values were subjected.

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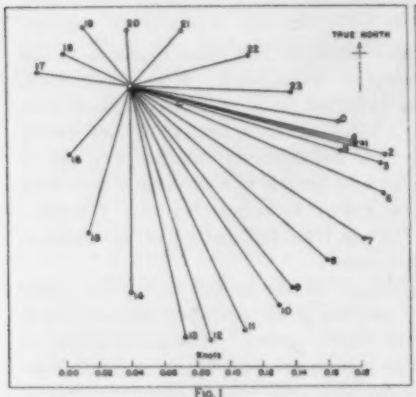

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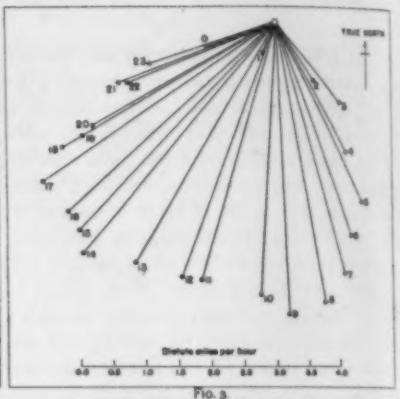


FIG. 3

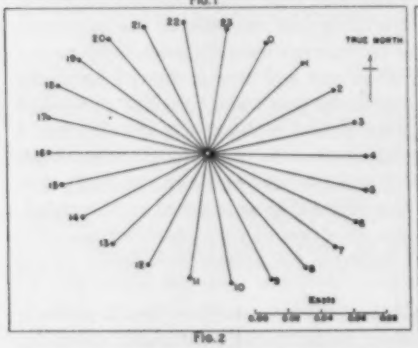
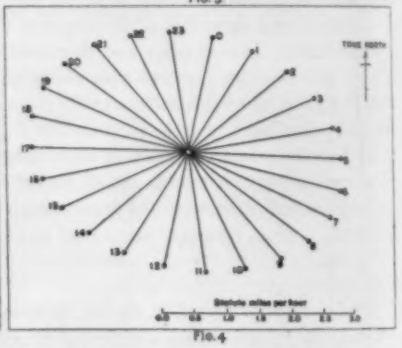


FIG. 2



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combined with similar effects in the results of Figure 3 but is eliminated from the results of Figure 4.

Direction and Velocity Relations of Current to Wind

The tabular values given above show that the maximum and minimum phases of the daily current set in a direction 3.4° to the right of that of the corresponding phases of the daily wind. However, the time relation of the two movements is such that for the various hours of the day the average deviation of the current direction to the right of the wind direction is 10° more than the above value, or 13.4°. The values for velocity show that for the current as well as for the wind the minimum velocity is very close to three-fourths of the maximum. As determined from the tabular velocities the maximum current velocity is 4.76 per cent of the maximum wind velocity and the minimum current velocity 4.95 per cent of the minimum wind velocity.

From observations at a number of lightships along our Atlantic coast it was found that in general along this coast the wind current set about 20° to the right of the wind and that its velocity was about 1.5 per cent of the wind velocity.[5] These values differ somewhat from those obtained in the present investigation, but the wind velocities were much larger—10 to 60 statute miles an hour—and the winds and currents were nonrotary.

Rotary Diurnal Movements May Occur Generally

It appears probable that a daily rotary wind and a daily rotary current such as exist at St. Johns Lightship are not limited to that locality but are of more or less general occurrence along the continental coasts. It may be mentioned that the lightships stationed along the coasts of the United States afford an excellent opportunity for obtaining at nominal cost observations of current velocity and direction. During the last quarter of a century, through a coöperative arrangement with the Lighthouse Service, the Coast and Geodetic Survey has obtained long observational series at a number of the lightship stations.[6] Among many interesting conditions revealed by the lightship observations along our Atlantic and Pacific coasts are the rotary nature of the offshore tidal currents, their direction changing progressively from hour to hour, and the consistent deviation of the direction of the wind current to the right of the wind direction.

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[5] See *Current Tables, Atlantic Coast, North America, for the Year 1936*, U. S. Coast and Geodetic Survey, Washington, 1935, p. 143.

[6] This information appears in various forms in the annual *Current Tables* and other publications of the Coast and Geodetic Survey.

A SOUTH AMERICAN CIRCUMNAVIGATION

AN APPRECIATION OF "OCEANIC BIRDS OF SOUTH AMERICA" *

The journey upon which we are embarking has never before been undertaken. I propose to skirt the continental coast line, with full disregard of distance, time, and circumstance. Neither weather nor current need retard us; no island of the surrounding seas shall be too remote for us to reach within a twinkling; moreover, we may view the successive prospects, as preference dictates, either through eyes of today or those of generations long departed.

THIS journey on which Dr. Murphy takes us, which is designed as a setting for the main part of "Oceanic Birds of South America," suggests a novel approach to the geographical study of that continent. By focusing on this particular group of organisms, found here in unrivaled wealth and variety, the entire chain of life in the sea and the forces contributing to its functioning are brought to our consideration—the topography of the adjacent lands and the sea floor, the land drainage, the climate, the ocean currents. The configuration of South America, with its bold and simple lines, lends itself admirably to such treatment. To give a satisfactory presentation of the salient features from the Caribbean to the Scotia Arc and back to the Gulf of Panama demands a regional treatment. Dr. Murphy recognizes 14 regions: they are named in the caption to Figure 1. The geographical importance of this treatment is the greater because geographers have practically ignored oceanographical regions.[1] The sole systematic essay at oceanographical regional subdivision is that of Gerhard Schott.[2]

Some Boundaries

Dr. Murphy's regional subdivision of the littoral and waters about South America is informal but nonetheless suggestive, especially in regard to boundaries. "The boundless ocean"; "the freedom of a bird"—these figures of speech furnish a not unfaithful reflection of our general view of the ocean and its creatures. On the contrary, says Dr. Murphy, the ocean "abounds in invisible walls and hedges," and "the majority of oceanic birds are bound as peons to their own specific types

*Robert Cushman Murphy: Oceanic Birds of South America: A Study of Species of the Related Coasts and Seas, Including the American Quadrant of Antarctica, Based upon the Brewster-Sanford Collection in the American Museum of Natural History, 2 vols., The American Museum of Natural History, New York, 1936. The work is divided into two parts. Part I includes a discussion of "The Geographic Background" and "The Hydrology in Relation to Oceanic Birds" (Vol. 1, pp. 35–110); and "An Ornithological Circumnavigation of South America" (Vol. 1, pp. 110–322). Part II (Vol. 1, pp. 323–640, and Vol. 2, pp. 641–1178) is devoted to a series of bird biographies, in which a total of 183 species and subspecies from five orders are considered: the aspects stressed are the distributional, concerned with geographical responses, and the behavioristic, concerned with psychobiological responses. There is a bibliography of 32 pages.

[1] At the recent symposiums on regions held by the Association of American Geographers there was no mention of oceanic regions. See *Annals Assn. of Amer. Geogrs.*, Vol. 24, 1934, pp. 77–122, and Vol. 25, 1935, pp. 121–174; résumés in *Geogr. Rev.*, Vol. 24, 1934, pp. 309–311, and Vol. 25, 1935, pp. 321–322.

[2] Beginning with a regional classification of the Atlantic in "Geographie des Atlantischen Ozeans," 1912, Schott extended the principle to the Pacific and Indian Oceans in 1935. On the basis of an advance proof of the map of these latter, a world picture of the oceanographical regions was presented by W. L. G. Joerg at the sixteenth annual meeting of the American Geophysical Union in 1935 (The Natural Regions of the World Ocean According to Schott, *Trans. Amer. Geophys. Union, Sixteenth Ann. Meeting, April 25 and 26, 1935*, Washington, 1935, Part 1, pp. 239–245). Dr. Schott has informed the Society that he plans publication of a world map of the oceanographical regions in the June, 1936, number of *Petermanns Mitteilungen*. A discussion of this map together with a review of his "Geographie des Indischen und Stillen Ozeans" will be published in the October, 1936, number of the *Geographical Review*.

of surface water." Some of these oceanic boundaries can actually be seen and felt by even the casual observer. The rips and foam lines off the Galápagos visibly proclaim the boundary between the Humboldt and the Equatorial Currents. "The mixture sometimes results in alternating bands of surface water which differ in temperature by 5° or 10° C. or even more. Surface temperatures as low as 14.7° C. on one coast of an island, with very warm water on the other, were observed with astonishment by Darwin and Fitz Roy."

Zoögeographically the oceanic regions are for the most part defined by the distribution of nutrient matter and the life it supports, which in turn is largely determined by temperature and movements of the water. "Layers of ocean water of markedly different temperatures and salinities present to each other a surface of discontinuity, and behave more or less as though they were separated by a solid wall. Neither heat nor the substances dissolved in the water are readily exchanged between the two." Oceanographers are generally adopting the term "convergence" for such boundaries. They form the physical basis of the zones. In the waters about South America the following zones are recognized: Antarctic, Sub-Antarctic, Sub-Tropical, Tropical.[3] A temperate oceanic zone is practically eliminated (unless the anomalous Humboldt Current region of the Pacific coast may be so regarded) because of the "vast geographic influence of the polar regions upon a 'water hemisphere.' " The well defined Antarctic Convergence, between the Antarctic and Sub-Antarctic Zones, is an important faunistic boundary; roughly it corresponds to the extreme northern limit of pack ice. The latitudinal arrangement of the other zones is more disturbed by currents; the boundary between the Sub-Tropical and Tropical Zones, in particular, is ill defined. The boundaries, of course, are not fixed; they shift seasonally to some degree and more extensively at longer intervals. Major departures from the normal are particularly instructive. The classic example is the displacement of the northern part of the cool Humboldt Current by the warm countercurrent El Niño. Dr. Murphy has described in the *Geographical Review*[4] the abnormal displacement of 1925 and the ensuing train of consequences.

In classifying his birds ecologically as littoral, inshore, offshore (as far as the edge of the continental shelf), and pelagic Dr. Murphy also invites consideration of the boundaries between land and water. These boundaries too are not sharply defined. Relations between land and sea are by no means simple in their effect on the biota. Terrigenous deposits are very important; even small, intermittent streams may exert a not inconsiderable seasonal influence on oceanic life, and the influence of such streams as the Amazon and the La Plata is enormous. A phenomenon of the utmost importance is the upwelling of coastal waters as a result of offshore movement of the surface water. The classic example is the upwelling between the Humboldt Current and the coast. Off oceanic islands, especially if set

[3] As to the boundaries and positions of these zones, the author (see his Fig. 6, Vol. 1, p. 67) follows the practice developed by the oceanographers of the Discovery Committee of the British Colonial Office (G. E. R. Deacon: A General Account of the Hydrology of the South Atlantic Ocean, *Discovery Repts.*, Vol. 7, 1933, pp. 171–237, see pp. 190–193 and Fig. 11; *idem:* Nochmals: Wie entsteht die Antarktische Konvergenz? *Annalen der Hydrogr. und Marit. Meteorol.*, Vol. 62, 1934, pp. 475–478, see Pl. 61; and D. D. John: The Second Antarctic Commission of the R.R.S. *Discovery II*, *Geogr. Journ.*, Vol. 83, 1934, pp. 381–398, see pp. 383–384 and Map 2). The usage adopted among German oceanographers differs from this, as Gerhard Schott points out (Geographie des Indischen und Stillen Ozeans, Hamburg, 1935, p. 163). In the German classification the Antarctic Zone consists of two zones, the Sub-Antarctic and the Antarctic, and the Sub-Antarctic Zone of the British school is designated Zone of Mixed Waters; both systems agree in the designation and position of the Sub-Tropical Zone. The German system, especially as regards the Sub-Antarctic, would on the whole seem to fit better into a regional subdivision of world-wide scope based on a broad range of physical criteria and not on oceanographical data alone (compare Chapter VI and Figures 23–24 in Otto Nordenskjöld: Polar Nature: A General Characterization, *in* The Geography of the Polar Regions, *Amer. Geogr. Soc. Special Publ. No. 8*, 1928, pp. 3–90).

[4] R. C. Murphy: Oceanic and Climatic Phenomena along the West Coast of South America during 1925, *Geogr. Rev.*, Vol. 16, 1926, pp. 26–54.

athwart a current, upwelling may produce significant effects. The extraordinary richness of the waters about South Georgia is a well known case. Striking examples come likewise from the warm seas. The food of pelagic birds is made up chiefly of schooling organisms, whether fish, cephalopods, or crustaceans, and in the centers of high pressure such forms belong to the depths rather than the surface waters. As far as oceanic birds are concerned, the Sargasso Sea, for instance, is a desert. On the *Dana* expedition in 1920–1921 "the fewest birds were noted toward the center of

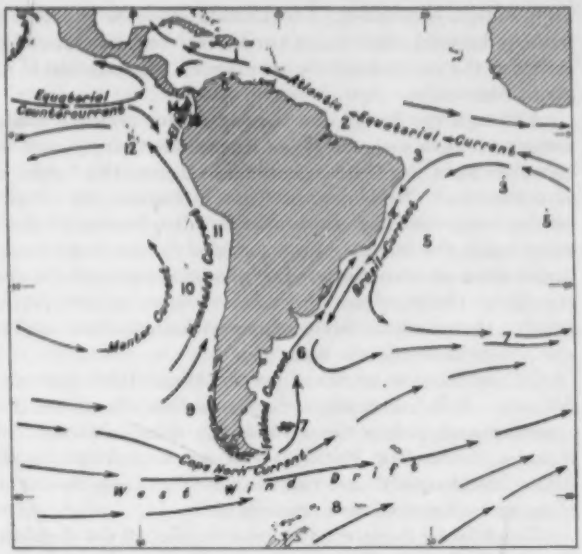


FIG. 1—Schematic map showing the principal ocean currents of the waters adjacent to South America (reduced from Fig. 8, p. 84, of "Oceanic Birds of South America"). Regional subdivision is suggested by the additions of numbers:

1. The Caribbean Region
2. Northeastern Atlantic (Trinidad to Recife)
3. Atlantic Equatorial Islands
4. Central Atlantic (Recife to La Plata)
5. Atlantic Sub-Tropical Islands
6. Southern Atlantic
7. Atlantic Sub-Antarctic Islands
8. Scotia Arc
9. Eastern Fuegia to Central Chile
10. Pacific Sub-Tropical Islands
11. Desert Coast (Coquimbo to Pt. Pariñas)
12. The Galápagos
13. Northern Peru to Panama
14. Tropical North Pacific Islands.

Reference should be made to Dr. Murphy's map of South America showing the adjacent ocean and islands with drainage and precipitation on land and the relations between air and water temperatures on the sea (Pl. 2, facing p. 35) and to the individual location maps for the several regions, especially the large scale maps of various islands and island groups.

the Sargasso Sea, where the average was sometimes as low as one bird per day for periods up to 99 days." Islands in the tropical seas may be veritable oases. "Around St. Paul Rocks, which rise from great depths, the 'Meteor' party found the largest plankton concentration of an entire cross-section of the equatorial Atlantic."

The South American coasts may be divided broadly into Pan-Tropical (Tropical and Sub-Tropical) and Pan-Antarctic (Antarctic and Sub-Antarctic) moieties, the point of division being much farther north on the Pacific than on the Atlantic on account of the cooling effect of the Humboldt Current. The Pan-Tropical section, from northernmost Peru to southern Brazil, is an 11,000-kilometer stretch characterized by the presence of reef corals and mangroves (the range of the feral coconut is not very different), the Portuguese man-of-war, flying fish, dolphins, the frigate bird, tropic birds, and equatorial types of boobies. The southwest half is characterized by the giant kelp, Sub-Antarctic seals and sea lions, penguins, white-breasted cormorants, the wandering albatross, and the Cape pigeon.

THE REGIONS

In the section of the tropical coast eastward from the Isthmus of Panama five subdivisions are recognized. The northeast coast under the influence of the powerful

Equatorial Current embraces the Caribbean and Northeastern Atlantic Regions.

The Caribbean Region (1) is distinguished by its numerous islands. On the tropical coasts it is the continental rather than the oceanic element that predominates. The islands, especially the remote islets, such as the Islas de Aves and Los Hermanos, are important centers for oceanic birds, largely because of the safety they offer. Boobies and man-of-war birds and to a lesser extent terns and pelicans flourish. On the mainland, on the contrary, west of the Goajira Peninsula and particularly along the jungle borders of Darien, oceanic birds are scarce, save for a ubiquitous cormorant. Local conditions—the presence of suitable habitats—are more influential than zonal conditions, and this coast shows much variety; for instance, the range from the very heavy precipitation of Urabá to the high aridity about Maracaibo.

Although the Atrato and the Magdalena pour out vast quantities of fresh, silty water to mingle with the saline Equatorial Current, still more powerful is the contribution from the Orinoco and the Amazon, the "chief sluice-way of the wettest of continents" (Northeastern Atlantic Region, 2). Their muddy waters seem to be the factor limiting the southward distribution of the brown pelican. On the other hand, the fluviatile waters carried far out to sea have a favorable effect on the distribution of other birds. For 900 kilometers off the Amazon mouth the *Meteor* expedition remarked sea-bird concentration and attributed it to the reduction of salinity, the enormous terrigenous additions, the local zones of sinking and upwelling and active mixing of the waters.

Off the shoulder of Brazil lies the Rocas Reef, the only true atoll in the South Atlantic. Still farther out is Fernando Noronha, whose bold Pyramid is "the most arresting landmark in the whole South Atlantic Ocean." With these Dr. Murphy includes the St. Paul Rocks, farther north, and remote Ascension, halfway toward Africa, as Atlantic Equatorial Islands (3). These no doubt are the ultimate source of many marine species of tropical birds.

The Atlantic Equatorial Current divides off the shoulder of Brazil. One branch, the Brazil Current, sweeps the Brazilian coast as a warm, highly saline stream (Central Atlantic Region, 4). The upper waters of the open ocean in this region are too warm to support an abundant life; but the presence of islets and banks, such as the Abrolhos, has a locally enriching effect. In the southern part an eddylike current, the São Sebastião, hugs the coast with cooling effect eastward to Cape Frio. It illustrates well the influence exerted by even a small temperature difference in the tropics.

In the category of Atlantic Sub-Tropical Islands (5) are placed South Trinidad (Trindade), 1200 kilometers off Cape Frio, Martin Vas, 50 kilometers farther east, and St. Helena. St. Helena is actually nearer Africa than South America, but it serves as a link in the distributional chain of South Atlantic birds. That St. Helena is near the Pan-Tropical–Pan-Antarctic boundary is suggested by the presence of Antarctic Zone birds in the vicinity.

The meteorological differences between the subtropics and the Sub-Antarctic are pronounced: it is a passage to sharp and sudden changes of temperatures and winds. The area from the Gulf of La Plata to Magellan Strait (6) is under the influence of the strong westerlies and the cool Falklands Current. The Gulf of La Plata is another strange meeting place of incongruous forms of life. Remains of tropical vegetation are carried hundreds of miles out to sea, but the sea birds frequenting the offshore fringe of mixing waters are of anything but tropical facies.

Included in the group of Atlantic Sub-Antarctic Islands (7) are the Falklands and the very remote Tristan da Cunha and Gough Islands. The oceanic bird life of these Sub-Antarctic Islands has many elements in common. Before the invasion of settlers the Falklands were a paradise of Sub-Antarctic bird life; now sheep and birds—the upland goose, for instance—compete for the pastures. The nearness of

the Falklands to the mainland is seen in the extensive migration of birds to these islands during a year of continental drought.

Gough Island is 2500 kilometers from the Cape of Good Hope and 3000 kilometers from Cape Horn; the Tristan da Cunha Islands are some 400 kilometers northwest of Gough. The weather at the two is not very different; but it is severer at Gough, since it lies well within the Sub-Antarctic Zone, whereas Tristan da Cunha is close to the convergence with the Sub-Tropical Zone. Gough has six bird species in common with the Falkland Islands and a larger number of related forms distinct in either species or subspecies. It lacks the cormorants, grebes, ducks, geese, swans, and shore birds represented in the Falklands and has only a rail and a finch as indications of zoögeographical bonds with the continents. The Tristan da Cunha group has all the native sea birds found on Gough except the giant fulmar, Gough apparently representing the closest approach of its nesting range to the Sub-Tropical Convergence.

The South Polar lands stretch farthest north in the Antarctic Archipelago, connected with Tierra del Fuego by the loop of islands and submarine ridges known as the Scotia Arc (8). The contrast between the Antarctic islands and the Sub-Antarctic lands is profound, yet the northward extension means relatively favorable conditions; 10 species of birds have a local foothold in the Antarctic Archipelago, and stray continental birds are frequent. There is, moreover, a difference between the east, or colder, side and the west, or warmer, side; several penguins, for instance, breed farther south on the open west shore than on the Weddell Sea shore.

Although the latitudinal difference between the Sub-Antarctic Falklands and Antarctic South Georgia is not great, it is well defined. Sheep, which flourish at Kerguelen Island as well as in the Falklands, cannot survive in South Georgia. About it and the other islands of the Scotia Arc is a famous whaling ground, and whaling has had extraordinary repercussions on the bird life. Excessive numbers of birds are attracted to the whaling operations; and one bird, Wilson's petrel, has actually acquired a new feeding technique to take advantage of the new food source. Although far to the east, Bouvet Island is included with this group as a station in the eastward distribution of sea birds originating in the American quadrant of the Antarctic. It marks the eastern limit of the Antarctic ringed penguin. The effect of island-bird guano on the plankton enrichment of the surrounding waters is well illustrated at Bouvet.

No voyager can fail to remark the extraordinary contrast between the two ends of Magellan Strait: "The western half is grand and solemn, with its deep waters mirroring white crags and blue glaciers. The low eastern half has no beauty save that which belongs to vast open spaces of level land and smooth water over which broods the silence of a clear and lucent air" (Bryce). The contrast extends northward on the two sides of Patagonia and has various echoes in bird distribution. The maze of channels on the west is one factor favoring the abundant but little-known bird life of western Patagonia. On the east notoriously high tidal range is a disadvantage to certain species. As regards species range, a lower summer temperature on the west coast (winter temperatures are higher) governs the extension farther northward of cooler-zone forms: species of geese, steamer ducks, shags, and oyster catchers not met with on the east coast beyond the Falklands and southern Patagonia extend on the west coast to Chiloé. Chiloé itself, with the shoals, currents, kelp, and shellfish of its shores and the lakes and morasses of the interior, is a waterfowl paradise surprisingly little known. If we knew of Chiloé only what Darwin wrote a century ago, we should be relatively up to date, says Dr. Murphy. Beyond the Patagonian portion of the region "Eastern Fuegia to Central Chile" (9) a subregion of gradual transitions follows the Chilean seaboard northward. At Mocha (38° S.) "blue skies may be said to begin. Mere fogs and mists here tend to supplant in part the pounding rains of Chiloé." At the Río Limarí (30° 45′ S.) "the spell of the desert is foretold."

Before proceeding to this most interesting region we are taken to the Pacific Sub-Tropical Islands (10)—Juan Fernández and San Ambrosio and San Felix, on the same submarine ridge 700 kilometers farther north, are definitely outside the Humboldt Current. The islets of Sala y Gomez (26° 25′ S. and 105° 25′ W.), outside the South American avifaunal sphere, it may be noted are significantly a breeding ground for certain pantropical sea birds unable to establish themselves in the Humboldt Current region.

The extraordinary character of the desert littoral of Peru and northern Chile (11) was noted by scientific observers long ago. On the voyage of the *Vénus* Du Petit Thouars in 1838 recorded sea-water temperatures of 15.2° C. at Valparaiso, 16.7° at Callao, and 17.7° at Paita, an increase of only 2.5° in 28° of latitude, which De Tessan, who reported on the physical oceanography, correctly ascribed to upwelling of the coastal waters—the first direct reference to this phenomenon. The uniformity of the coast and littoral is shown by the remark that more change is experienced in an hour's westward sail across the current than in a week's sail north or south. Associated with the continuous upwelling of the coastal waters is the profound contrast between the arid land and the rich life of the sea, its fauna "nonconforming and eclectic," in many respects temperate rather than tropical in facies. However, the arid interior is not devoid of avifaunal interest. Certain little-known birds, such as petrels and shearwaters, seek its remote wastes as breeding grounds safe from depredation. The bird life of the Humboldt Current has long been of practical human interest in its relation to the guano deposits of the islands off the Peruvian mainland, and it has often been described. Frank M. Chapman's graphic account is selected by Dr. Murphy for quotation. It begins:

"As for the birds, who can describe them in their incalculable myriads? Visible link in the chain of life that begins with diatoms nourished by the cool, highly oxygenized waters of the Humboldt Current, they animate both the air and the sea. No other coastline of similar extent can show an avian population equaling that of the waters off Peru.

". . . Birds could be seen in countless numbers fishing in dense, excited flocks, passing in endless files from one fishing ground to another, or massed in great rafts on the sea. Toward the shore long, waving whip-like streamers and banners passed in endless undulating lines sharply silhouetted against the coast range.

"Seaward, like aërial serpents, sinuous files crawled through the air in repeated curves lost in the distance, while low over the water processions passed rapidly, steadily, hour after hour, with rarely a break in their ranks during the entire day."

As one approaches the critical zone in the north, where the cool current meets tropical waters and where "desert begins to give way to land that knows a rainy season," new signs and symbols break the prolonged uniformity. The surface rock of Lobos de Afuera and Lobos de Tierra, for example, shows the peculiar glazing that marks certain islands of the humid-arid boundary and that seems to be due in part to the action of humidity on guano. Barrington Island, in the Galápagos, shows the same effect. Off the mainland the Galápagos (12) lie in the boundary zone and exhibit a mingling of faunas without parallel—fur seals and penguins with flying fish and tropic birds. The ocean waters tend to show the feature, unusual for such latitudes, of a negative temperature anomaly compared with the air. Transient reversal of this state indicates the invasions of El Niño, to which reference has already been made. The borderline region of the Galápagos is one peculiarly fruitful for research.

The boundary between the cool arid and the warm humid regions can be traced with unusual precision on the islands and mainland of Ecuador. El Muerto Island, normally arid, is noteworthy as the southernmost nesting place of two or more pantropical sea birds. The last spot reminiscent of the desert, Pelado Island, lies a little farther north; its guano deposits contrast with the green of the opposite

mainland. At Salango Island, some twenty miles north of Pelado, Dr. Murphy brings us to what he calls the threshold of a section of the Tropical West Coast (13) extending to Panama that is very little known to naturalists, chiefly because of the length of the rainy season and concomitant difficulties of transportation. Included in a separate group are the Tropical North Pacific Islands (14)—Cocos Island, Malpelo Island, and the Pearl Islands.

Geographical Description

This outline of geographical facts and forces underlying "Oceanic Birds of South America" scarcely hints at the resourcefulness of the treatment and the wealth and variety of detail embraced within a relatively small compass—brilliant sketches of little-known places and unusual phenomena, suggestive allusions and comparisons. There is, for instance, the picture of Mexiana, at the Amazon mouth, "a typical example of Atlantic equatorial lowland fronting on the ocean," and the succinct history of guano exploitation off the Peruvian coast; the "rollers" of Ascension are compared with the "resacas" of the Brazilian coast and the "surf days" of the nitrate and guano ports; the shallowness of the trade winds at St. Helena, sometimes only 50 meters deep, is noted, and the extraordinarily variable rainfall of Fernando Noronha, which in a 20-year period ranged from 460 to 2396 millimeters.

Dr. Murphy draws on his own experiences in three fruitful voyages—one to South Georgia, two to the Peruvian littoral—and on much contemporary field work, including many collecting expeditions undertaken expressly for the American Museum of Natural History. And he makes no less extensive excursions into the literature of earlier expeditions. Quotations from the reports of the *Meteor* expedition find place by the side of quotations from Darwin's account of his voyage in the *Beagle*. Wilkins is cited, "one of the best bird watchers who have ever served in the far south," and even that "redoubtable and justly maligned seafarer," Captain Benjamin Morrell! The quotations alone form an interesting anthology. And here the geographer may take another hint. Too often, it seems, the *art* of geographical description of the early naturalist-travelers is a lost art. No science offers its exponents better opportunity for artistic presentation and to that extent for reaching a wide and appreciative audience. Popular imagination and understanding can be stirred, as Sir Richard Gregory, editor of *Nature*, puts it, by clothing our findings "in garments of blissful words and radiant phrases."[5]

This is from Dr. Murphy's own description of the "fairy island" of Trindade: "Alone in the tropical ocean, piled up in peaks as fantastic as tossing waves, and overhung with pennons of torn clouds which seem to flutter from the summits, Trinidad has exercised a strange charm upon the imaginations of all who have but seen its silhouette on the borderline of sky and sea. During four centuries it has been a landmark in the trade routes of the South Atlantic, often sought by sailing vessels as a check upon their nautical reckonings. Before the days of steamers it was a veritable signpost at a crossroads of the sea, yet few indeed are the travelers who have set foot upon its crumbling shore. Pirates in the old times, whalers, treasure-seeking adventurers, ill-fated colonists, in their turn have come to Trinidad and gone; the island seems unfalteringly to forbid the encroachment of permanent habitation." And this of Fernando Noronha: "When the trades are strongest, a spectacular surf pounds the windward coasts of Fernando Noronha. During the season of calms, on the other hand, the more sheltered shores are singularly peaceful. Curving beaches of sand run down to quiet, pale green coves, the hue of which is reflected from the white breasts of sea birds flying overhead."

[5] Interpretation of Science, *Science*, Vol. 83 (N.S.), 1936, pp. 357–363; reference on p. 363.

AMERICAN GEOGRAPHICAL SOCIETY

The March Meeting. The regular monthly meeting of the American Geographical Society was held on March 24, 1936, at the Engineering Societies' Building, 29 West 39th Street, Mr. Philip W. Henry, Chairman of the Council, presiding. Dr. Barnum Brown, Curator of Fossil Reptiles at the American Museum of Natural History, delivered a lecture entitled "A New Dinosaur Kingdom." Dr. Brown has conducted expeditions in search of dinosaur remains in North and South America, Europe, Asia, and Africa and is the discoverer of several of the more important deposits in the United States. His lecture dealt with the American Museum–Sinclair Expedition of 1934, on which the fossils of a new dinosaur herd were discovered and excavated in northern Wyoming and the importance of the airplane in locating possible sites was demonstrated in a series of flights totaling 20,000 miles. The lecture was illustrated with colored lantern slides and motion pictures.

The April Meeting and Presentation of the David Livingstone Centenary Medal to Lincoln Ellsworth. The regular monthly meeting of the American Geographical Society was held on April 21, 1936, at the Engineering Societies' Building, 29 West 39th Street, President Redmond in the chair. The meeting was the occasion of the presentation of the David Livingstone Centenary Medal for 1936 to Mr. Lincoln Ellsworth. In making the presentation Mr. Redmond spoke in part as follows:

"We have met tonight to pay honor to an explorer who through the skillful use of modern inventions has done as much as any man to solve the last great secrets of exploration. Lincoln Ellsworth is a modern explorer in every sense of the word. With Amundsen, he was the first to make effective use of both airplane and airship as a means of polar exploration—in 1925, when by airplane a point only 136 nautical miles from the North Pole was attained, and in 1926, on the *Norge* from Spitsbergen to Point Barrow.

"Having successfully completed these two Arctic flights, Mr. Ellsworth turned his attention to the still more difficult problems of the Antarctic. In 1933 he planned a nonstop flight from the Ross Sea across the Antarctic Continent to the Weddell Sea. This expedition came to a sudden end when the plane, which had been specially designed for the flight, was crushed in the ice in the Bay of Whales. Undaunted he returned to the Antarctic in 1934 to an attack in the reverse direction. Unfavorable flying conditions and motor trouble made a flight impossible that season. Instead of discouraging Mr. Ellsworth, these two disappointments spurred him on to greater efforts, and, with that perseverance that is the mark of all true explorers, he returned to the Weddell Sea in 1935. On his final accomplishment I need not comment, since he will tell you of it himself. But, knowing his modesty, I should point out the epic quality of that accomplishment. Launched on a long and hazardous flight across the unknown, their communication cut off by failure of their radio, he and his intrepid pilot landed again and again in an icy wilderness where the least accident meant disaster, calmly made their observations, waited for favorable weather, and then took off again for their distant objective, navigating with such accuracy that when their fuel was exhausted they were within 20 miles of their goal. Such an achievement ranks high indeed in the annals of exploration.

"To Lincoln Ellsworth, explorer extraordinary, pioneer in the use of aircraft in polar exploration, and the only man who has flown across both the Arctic Sea and the Antarctic Continent, it is a pleasure and an honor to present, on behalf of the American Geographical Society, the David Livingstone Centenary Medal, awarded 'for scientific achievement in the field of geography in the southern hemisphere.'"

After responding, Mr. Ellsworth told the story of his flight. This was illustrated with still and motion pictures. A discussion of the important documentary evidence

of the photographs appears on pages 454–462 of this number of the *Geographical Review*. The meeting was closed with a tribute to Mr. Ellsworth by Dr. John H. Finley, Honorary President of the Society.

Election of Councilor. At the meeting of the Council of the Society held on April 8, Mr. Lincoln Ellsworth was elected Councilor of the class of 1939.

Field Marshall Viscount Allenby of Megiddo and Felixstowe. Lord Allenby died in London on May 14 in his seventy-sixth year. He was elected to Honorary Membership of the Society in 1932 (*Geogr. Rev.*, Vol. 22, 1932, p. 304). His contribution to geography lay in his knowledge of the Near East. This was well expressed on the occasion of the award of the Livingstone Gold Medal of the Royal Scottish Geographical Society (*Scottish Geogr. Mag.*, Vol. 42, 1926, p. 361): "The success of the campaign conducted by Lord Allenby (1917–18) in Egypt, Palestine, and Syria was to a large extent due to the keen appreciation possessed by the Commander-in-Chief of the essential facts of geography, both topographic and climatic; . . . the occupation of these countries by Viscount Allenby's army was marked by a great advance in geographical knowledge of the region, more especially by the production of an accurate map; . . . by his military success and subsequent administration Viscount Allenby had been instrumental in throwing widely open to future research in geography and allied sciences and studies the door of a country of fundamental importance to them."

It has been said that Lord Allenby "belongs not alone to the company of the great soldiers of all time. He has also a rightful place with the first statesmen of peace." Peace he sought by active measures. Speaking as chairman of the Central Asian Society he pleaded the responsibilities of that society in Eastern questions and called for "a clearly defined policy, honestly and openly expressed, . . . remembering that history holds no excuse for those who let things slide."

The Wood Yukon Expedition of 1936. To continue the program of mapping from high oblique aerial photographs begun in 1935 in southwestern Yukon Territory, an expedition under the leadership of Mr. Walter A. Wood left New York early in June. Because of inclement weather during 1935 the field program was not completed (see *Geogr. Rev.*, Vol. 26, 1936, pp. 228–246), and in order to grasp every opportunity the weather affords as well as to complete the survey as efficiently as possible the expedition is taking its own airplane. This was made possible through the coöperation of the Canadian government, which granted the expedition permission to fly over and make a base on Canadian soil. The expedition is under the auspices of the Society.

GEOGRAPHICAL RECORD

NORTH AMERICA

The Climate of the Region About the Gulf of St. Lawrence in Relation to Aviation. Northeastern Canada, Newfoundland, and the neighboring waters form a region across which will lie the shortest air routes of the future connecting Europe and the main centers of population in North America. This region is also one where local airways should be of increasing value because of the isolation of the settled areas and their separation from one another by arms of the sea. Fog, rain, snow, cloudiness, and frequent low ceilings form serious obstacles to the development of aviation. These aspects of the climate are described in detail and illustrated by an interesting group of maps and graphs in the first of a new series of studies published by the Meteorological Service of Canada (W. E. K. Middleton: The Climate of the Gulf of St. Lawrence and Surrounding Regions in Canada and Newfoundland, As It Affects Aviation, *Canadian Meteorol. Memoirs No. 1*, Ottawa, 1935). Particular attention is devoted to fog and "thick weather," especially to their geographical distribution, seasonal and diurnal variation, and duration. At Cape Race, Newfoundland, one of the foggiest places in the world, the average number of hours of "thick weather" in July is 429, or about six-tenths of the time. Twenty-two per cent of the continuous spells of "thick weather" here last more than 24 hours, and the greatest observed duration was 8 days and 1 hour. "The total annual snowfall over the region varies from 46 inches at Sable Island to 127 inches at Quebec . . . More important to aviation than the total snowfall, however, is the average number of days with snow . . . It is fairly certain that there is a region of high snow frequency on the west coast of Newfoundland, which probably extends into the hilly interior, and another region of high frequency in the interior of Quebec."

Rainfall Intensity-Frequency in the United States. "Rainfall Intensity-Frequency Data" by David L. Yarnell (*U. S. Dept. of Agric. Misc. Publ. No. 204*, 1935) gives the results of an investigation "to determine the frequency at which excessive rates of precipitation occur in different sections of the United States, and the intensity and duration of those rates." It comprises two tables, 76 maps and graphs, and a short interpretation. Table 1 lists the duration, total fall, and precipitation for 5-minute intervals of the most intense rainstorms recorded through 1933 at 208 well distributed Weather Bureau stations. Table 2 lists, for the same stations, the maximum rates of precipitation recorded for intervals of 5 minutes to 50 minutes, for 60, 80, 100, and 120 minutes, and, for some of the stations, for 3, 6, and 12 hours.

The maps show the amount of rainfall to be expected in periods of different lengths. The first series gives the rainfall, in inches, to be expected in five minutes once in 2 years, once in 5 years, in 10, 25, 50, and 100 years. Corresponding maps deal with periods of 10, 15, and 30 minutes and of 1, 2, 4, 8, 16, and 24 hours. Separate maps of the Pacific-coast states show by districts the 24-hour rainfalls to be expected in 5, 10, 25, 50, and 100 years. The final series of maps gives the number of "excessive rainstorms" per 30 years for each of the months.

Nearly all the maps, except the last series of 12, show a rather steady decline from the Gulf coast northward and also northwestward to eastern Oregon and Washington. The area of most intense rainfall on many of the maps is in the western part of the Gulf coast, especially southeastern Texas: the decline westward in Texas is markedly abrupt. Many of the maps show a pronounced northward bulge of the isohyets, even the northern ones, in the longitude of eastern Texas. A southward dip of the lines is common in the longitude of Ohio, but on many of the maps it fades out as the Gulf is approached. In the Rocky Mountain states the isohyets commonly trend roughly north and south.

Downpours of about half an inch in 5 minutes and nearly an inch in 10 minutes are to be expected once in a decade in much of the northeast quarter of the country; falls of 1.0 inch to 1.3 inches in 15 minutes and about 50 per cent heavier in 30 minutes occur in each decade in a large part of the east half of the country. Maximum hourly falls once in a decade range from 3 inches at the Gulf to 1.8 inches in Michigan and Massachusetts. During 2 hours totals one-third greater than in one hour are to be expected, and during 8 hours totals one-half greater at the north and twice as great (6 inches) at the south. In a day most of the east half of America can expect, once in a decade, one deluge of about 4 inches and the west half one of about 2 inches; the Gulf coast, however, can expect 7 inches and the Pacific coast about 5 inches.

The totals to be expected once in a century are of course greater than those to be expected once in a decade, but for the shorter intervals the increase is not great: for 1 hour to 8 hours the totals are about one-half greater, and for 24 hours somewhat more than one-half greater, than during each decade, especially along the Gulf, where 12 inches may be expected.

The monthly maps of "excessive rainfalls" reveal that such rains are practically confined to the southeast quarter during the cooler 4 months. From May to September, however, they are slightly the most frequent (about once a month per year) in or just south of the Corn Belt, except that in July and August some small areas in the southeast have relatively frequent excessive rains.

STEPHEN S. VISHER

The Eruption of Mt. Pelée, 1929–1932. The historic eruption of Mt. Pelée, on Martinique, which destroyed the city of St. Pierre in 1902, was followed by a period of quiescence, which lasted until 1929. During this interval the region about the volcano was repopulated. Preparations have been made by the government for the protection and evacuation of the inhabitants in the event of another catastrophe. Shelters and other places of refuge and a system of roads and paths have been constructed. Eight thousand persons removed from the area in 1929 were allowed to return after March, 1930. It is believed that about 7500 to 8000 people today occupy the potential danger zone. The population of St. Pierre was estimated at about 3700 in 1934 as compared with some 30,000 in 1902 (see Romer: L'éruption de la Montagne Pelée (Martinique) de 1929 à 1933, *Annales de Physique du Globe de la France d'Outre-Mer*, Vol. 1, 1934, pp. 129–147).

Mt. Pelée's recent phase of activity was less violent than that of 1902. The most dramatic and destructive manifestations of what Dr. Frank A. Perret calls the "Peléan type" of eruption are the *nuées ardentes*. It was one of these that destroyed St. Pierre. Incandescent bursts of liquid lava are propelled horizontally from the dome of the mountain and flow down the slopes, silently and at a terrific speed, often carrying with them great blocks of solid matter. Dr. Perret ascribes the rapidity and silence of movement to the fact that the component particles are isolated from one another by vapor films, which reduce friction. Over these avalanches rise the *nuées ardentes*, or "burning clouds," proper, "magnificently spectacular convolutions of vapor and ash, the swiftly unfolding cauliflower conformations of finer dust which mount upward" perhaps to a height of two or three miles (Frank A. Perret: The Eruption of Mt. Pelée 1929–1932, *Carnegie Instn. Publ. No. 458*, Washington, 1935).

Dr. Perret spent many months on Mt. Pelée at two different observation stations during the last period of activity. He gives a narrative of the eruption and a detailed analysis of its physics and mechanics, of the changes brought about in the shape of the mountain, and of many curious meteorological and other associated phenomena. He also explains certain criteria on which predictions of the future course of activity may be based. On one occasion a hot cloud of vapor and ash passed over the observation station, but Dr. Perret had the rare good fortune of living through it to tell the tale!

SOUTH AMERICA

Studies in the Vegetation and Climate of Peru. Dr. August Weberbauer has written a succinct account of the phytogeography of his adopted country as an introduction to the "Flora of Peru" (J. F. Macbride: Flora of Peru, Part 1, *Field Museum of Nat. Hist. Publ. 351, Botanical Ser. Vol. 13*, 1936, pp. 13–81). His vegetation map published in color in *Petermanns Mitteilungen* (Vol. 68, 1922, Pl. 13) is reproduced in black and white (for a résumé of the plant formations see *Geogr. Rev.*, Vol. 13, 1923, pp. 304–306). Continued travel and research have enabled Dr. Weberbauer to supplement and correct the material of his well known "Pflanzenwelt der peruanischen Anden" (1911). The discussion is regional. The data on limits, climatic and ecological, are especially valuable; for example, the special description of the Paita-Piura country of the "northern coastal region of deserts and semi-deserts." Its sparse herbaceous vegetation, "a mere veil through which the glitter of the sand is seen," is ecologically and floristically different from the loma vegetation of the coast of central and southern Peru. The former "owes its existence to a few showers, develops under high temperature, and is daily exposed to sunshine"; the latter "lives almost continually under a cloudy sky, in a damp, cool, foggy air." In the cold desert of the Puna there is a distinction between the vegetation of the rocks and stone fields and that of the earthy soils. On the rocks and stone fields, which warm to higher temperatures under the strong daytime insolation, vegetation is found at altitudes even above 5000 meters; on the earthy soils it does not reach above 4600 or 4700 meters. The tendency to aridity in the deep inter-Andean valleys is seen in extreme form in the Mantaro Valley at Mayoc (2250 meters), where the vegetation is similar in aspect to that of the cactus regions of the western Andean slopes. The montaña (upper limit about 1800 meters) is remarkable for the diversity of its formations, subxerophytic and xerophytic as well as hygrophytic. "Floristic investigations," says Dr. Weberbauer, "lead to the hypothesis that climatic changes have been the primary causes of the present multiplicity of formations." He points to elements from distant arid areas, especially central Brazil, that could not have migrated through tall rain forest and concludes that the forest must have been less extensive then than now.

In "Estudios climatologicos del noroeste peruano" (*Bol. Soc. Geol. del Peru*, Vol. 7, No. 2, 1935) Dr. George Petersen has brought together data on the climatic transition region of northwestern Peru that lies between the arid coast to the south and the humid Ecuadorian coast to the north. This study of fluctuations deals mainly with the 8-year period 1925–1932, a "humid" period. At the oil-wells station of Zorritos the average rainfall for the period was 610 millimeters; the minimum was 35 millimeters, in 1928, and the maximum 1872 millimeters, in 1932. A "pluviographic map" shows some abnormal rainfall limits in this period, and photographs illustrate the effects of exceptional rainfall. There are also backward glances, including an analysis of Francisco Pizarro's march in 1532. The belief has frequently been expressed that the famous march was made possible by its coincidence with an *año de abundancia*. Dr. Petersen gives reasons against the necessity of such an explanation.

The Llanos of Venezuela. "Die venezolanischen Llanos" (dissertation by Alfred Müller, Hamburg, 1934) is an important contribution to our knowledge of this little-known area. However, the statement that the clearing and burning of the woodlands (*Trockenhochwald*) have made it possible for grasslands to develop (p. 36) is incorrect. The grasslands are a natural phenomenon and are not due, at least in the western llanos, to the activity of man. Pre-Columbian watchtowers, causeways, and settlements, after four hundred years of disuse, are covered with grass and not with forest, as would surely be the case had they originally occupied mere clearings in woodland.

The natural regions in the western llanos are not well delimited. For instance, the area between Barinas and Pedraza, an extensive grassland crossed by the Santo Domingo, Paguey, and Canaguá rivers and their narrow gallery forests, is placed in the same region—*Grundwasserwald-Rotlehmebenen*—as the Ticoporo Forest, between the towns of Pedraza and Santa Barbara, which contains no grassland at all. A narrow region of gallery forest–park landscape (*Galeriewald-Parklandschaft*) is delimited, whereas this type of landscape is characteristic of large areas in the states of Portuguesa, Zamora, and Apure. Not being acquainted with the eastern llanos of Venezuela, I am unable to comment on the regional divisions in that area; but more field studies must be completed before a really comprehensive survey of the llanos as a whole can be made and the large natural provinces can be accurately delimited. Dr. Müller has done a valuable piece of work in assembling the existing material on this important area.

Dr. J. G. Myers, who visited the llanos in December and January of 1930–1931, recorded his observations in "Notes on the Vegetation of the Venezuelan Llanos" (*Journ. of Ecology*, Vol. 21, 1933, pp. 335–349). He describes the grasslands of the *llanos altos* (high llanos), between El Sombrero and Calabozo, as a kind of open parkland or savana, in which the grass *Cymbopogon rufus* predominates. In places this passes into "orchard" country, with scattered small trees of *Curatella americana* and *Bowdichia virgilioides*. In the *llanos bajos* (low llanos), from Calabozo to San Fernando, are vast expanses of typical low bunch-grass (*Cymbopogon*) savana, the country of Humboldt's classical description of the llanos. In the areas that are swamps in the wet season (*esteros*) grow short grasses distinct from those of the drier areas. Little is known of the effects of fire on edaphic savanas, but the high-grass savana of *Paspalum fasciculatum*, typical of low-lying areas, is dependent more on the deep annual inundations than on annual burning—which all the llanos suffer. However, many of the drier areas of the plains are overstocked during the dry season, and the close-grazing animals—horses and cattle—graze off the palatable grasses: in this way the llanos deteriorate as pasture.

Dr. Myers confirms Pittier's observation that "these llanos, which Humboldt pictured as being of uniform aspect, offer infinite variations in their very monotony." Parenthetically it may be noted that more recently Dr. Myers has recorded his observations on the "Savannah and Forest Vegetation of the Interior Guiana Plateau" (*Journ. of Ecology*, Vol. 24, 1936, pp. 162–184).

In "Desolate Marches: Travels in the Orinoco Llanos of Venezuela" (Harcourt, Brace, New York, 1936) the late L. M. Nesbitt, author of "Hell-Hole of Creation: The Exploration of Abyssinian Danakil" (see *Geogr. Rev.*, Vol. 25, 1935, pp. 689–690), narrates his experiences in northeastern Venezuela in 1927, where he was engaged in surveying an oil concession. He draws a vivid picture of the living conditions of the Indian and mixed-breed population. Many of them live in dilapidated thatch-roofed hovels with daub-and-wattle walls and are little better than serfs—exploited by the landowner, who may also own the store at which they trade. Their diet is mainly cassava and corn bread, occasionally varied with plantains and wild game. They are sallow and listless, emaciated by recurrent attacks of fever and dysentery, which, according to one of his informants, an ailing old cooper, were unknown in that area a generation ago. The simple Indians look upon the white man as a superior being, and passing strangers would ask the author to act as judge in their quarrels, as do the negroes of southwestern Africa (cf. Leo Waibel: Vom Urwald zur Wüste, 2nd edit., Breslau, 1928, p. 76).

The steady movement of the population of the llanos to the coastal towns or to the mountain towns, where a healthful climate can be enjoyed, is important. Those who cannot leave for good make desperate efforts to escape from the great plains before the rains set in. Depopulation of the llanos has been going on since the wars with Spain, and many explanations have been advanced to account for it. In the

opinion of the reviewer not enough emphasis has been placed on the partial breaking down, at the end of the wars with Spain, of the feudal slave-serf economy of the colonial period, when cacao, tobacco, and indigo were grown and transported to the ports by the labor of unpaid, ill-kept slaves. Once the planters were, to a great extent, deprived of forced labor and could no longer sell in the closed market of Spain, by which they were assured of high prices, it became unprofitable to grow these crops, and the economy of the llanos became based almost entirely on the grazing of cattle. Hence not so many workers were required as in intensive farming, and steady emigration has been the result. The reviewer furthermore believes that the negro element has played an important part in the evolution of the present *llanero* type (see R. E. Crist: Le Llanero, *Rev. de Géogr. Alpine*, Vol. 23, 1935, pp. 97–114).

RAYMOND E. CRIST

EUROPE

The Dunes of Polesia. Polesia is a country of oddly contrasted landscape forms—marshes and dunes. Elsewhere in this number of the *Review* (pp. 376–395) the marshes are described; the dunes are discussed by Stanislaw Pawłowski in the excursion guidebook to Polesia and Białowieża of the International Geographical Congress. In no part of Poland—of western Europe, in fact—do dunes cover such extensive areas as in Polesia. They are very well developed, for instance, in the valleys of the upper Prypeć and the Pina. The dunes evidently antedate the marshes, out of which many of them rise. Probably they were built in a drier postglacial period and fixed in a following more humid climate. Where the dunes have been denuded and attacked by the winds, they appear as desolate sandy plains, white in the gray green of the typical Polesian landscape. Rarely, however, has denudation occurred over long distances; for the most part the dunes are covered with pine forests.

Some of the dunes rise to 20 meters above their surroundings; to the natives they are "mountains" or, when they rise from the marshes, "islands." In many places they afford the only dry land surface, and they have been chosen sites of settlements and routes since the earliest times. This latter aspect Professor Pawłowski takes as the subject of his contribution to the *Festschrift* to Professor Švambera (Mélanges de géographie offerts par ses collègues et amis de l'étranger à M. Václav Švambera à l'occasion de son soixante-dixième anniversaire, Prague, 1936, pp. 109–115). He illustrates his "La dune et la route" with examples from the 1 : 100,000 map of the Institute of Military Geography of Warsaw.

Climate and Crop Yields in Belgium. Variations in plant growth and yields of food products as related to variations in meteorological factors are admittedly of much importance to the welfare of the earth's population. Yet even as late as 1924 R. A. Fisher, eminent English statistical biologist, stated that practically nothing was known on the subject. The years since then have supplied preliminary contributions on a few crops in a few areas of the world, chiefly the United States and western Europe. A recent contribution is "Recherche statistique des relations existant entre le rendement des plantes de grande culture et les facteurs météorologiques en Belgique," by R. Berce and R. Wilbaux (*Bull. de l'Inst. Agronomique et des Stations de Recherches de Gembloux, Belgique*, Vol. 4, 1935, pp. 32–81 and 350–365).

Using the weather records of Gembloux, Belgium, as typical of the most important agricultural region of the country, and official Belgian statistics of yields, mostly for periods of 13 and 27 years, the authors find by simple and partial correlation that the climate of Belgium tends to be too wet and cool for the best yields of winter wheat. Above-normal (5.5 inches) precipitation in November and December is especially unfavorable to the chances of abundant yield the following summer

($r = -.70 \pm .09$). December precipitation considered alone gives $r = -.67 \pm .10$. Partial correlation substantiates this conclusion by showing that, when July temperature is held constant, the November and December precipitation gives a coefficient of −.79, and when total solar radiation for July is held constant, a coefficient of −.81. Above-normal precipitation during any part of the period of growth and ripening is detrimental.

Above-normal temperatures and solar radiation during the spring and early summer are distinctly favorable and give for July coefficients of $+.67 \pm .10$ and $+.75 \pm .09$ respectively. When variations in November and December precipitation of the preceding autumn are eliminated by partial correlation, July mean temperature and July total radiation give respectively +.76 and +.83.

Some slight comparison by the authors with work done in France on the same crop suggests to the reviewer the possibility that a study of these relationships by means of samples from the wheat-growing areas of Europe might show very significant changes in the relationships from the marine type to continental and Mediterranean types of climate.

Similar studies of sugar beets showed that the yield of roots by weight tends to increase with increased rainfall, especially increased September rainfall ($r = +.81 \pm .07$), and with increased temperature in June, whereas increased solar radiation in July cuts down the weight. However, September rains decrease the percentage of sugar ($r = -.67$), and July solar radiation increases it ($r = +.67$). In view of the fact that factors that increase the weight of roots decrease the percentage of sugar, it is interesting to balance the effect by considering the yield in weight of sugar. Rainfall in May and September contributes to greater yield in weight of sugar ($r = +.56$). June solar radiation seems nearly as significant and also positive in its relation.

Winter barley and potatoes were also investigated, though without significant results.

JOHN KERR ROSE

AFRICA

Water-Supply Problems in East Africa. The Moshi and Arusha Districts of Tanganyika Territory, in which lies the Kilimanjaro-Meru massif, form a region where "rapid variation of all the geographical elements is exhibited within remarkably short distances . . . from plain to precipitous slope, from desert climate to humid tropical and temperate conditions and . . . to arctic desert and polar ice cap. . . . Diversity of soil texture, character and composition . . . introduces many apparent anomalies in the changing conditions for, and practices of agriculture and irrigation. . . . Superimposed on this very checkered natural basis is a highly developed native agricultural and irrigation system with long established customs and laws. This has recently been invaded by European enterprise, first under a determined German policy, later interrupted by the war period of instability, and now under British control. The whole complex thus provides a most fascinating study to the pure geographer but a situation difficult in the extreme for the ordinary administrator" (E. O. Teale and C. Gillman: Report on the Investigation of the Proper Control of Water and the Re-Organization of Water Boards in the Northern Province of Tanganyika Territory, November-December, 1934. Dar es Salaam, 1935).

Teale and Gillman's analysis of the water-supply problem in the Northern Province has an interest beyond the Territory. It merits the attention of all concerned with planning for the utilization of natural resources. The authors make abundantly clear the intricate nature of land-planning problems and the need for sound knowledge of the fundamentals. For instance, in this case of northeastern Tanganyika there is the necessity of knowing the actual sources of the water before plans can

be laid for its use. The prevailing notion that the icecap of Kilimanjaro is the main source of surface flow is challenged. On the contrary, the authors of the report stress the importance of the mountain forest belt. They confirm Klute's views on the rapid diminution of rainfall above the forest belt, and they point to extremely high evaporation at the high altitudes. They argue for the strict conservation of the forest belt as one of the most valuable, if not the most valuable, of the country's assets.

The Tana River, drawing from Mt. Kenya and the Aberdares, is the largest stream of Kenya Colony. For the last 500 miles of its course it receives no tributaries of importance. For years the development of this "East African Nile" has been advocated. In 1934 with the aid of airplane and motor lorry a reconnaissance survey of the river was made with a view to determining its possibilities for irrigation (D. G. Harris and H. C. Sampson: Report of the Tana River Expedition 1934, Colony and Protectorate of Kenya, Nairobi, 1934; see also H. C. Sampson: The Tana River Region of Kenya Colony, *Journ. Royal Soc. of Arts*, Vol. 84, 1935, pp. 92–109). The report expresses the opinion that irrigation development on the lower Tana is economically impossible and recommends a definitive survey of the upper basin on the strength of the authors' provisional conclusions that "the levels of the country in and around the upper Tana basin are such as to make an extensive irrigation project in that area feasible and, secondly, that there is sufficient suitable land within that area to utilize any supply which can reasonably be drawn from the river." The project is classed as protective rather than productive. In this respect it is justified "as a real endeavour to remove the spectre of future famine which . . . broods to-day over large areas of Kenya."

The British Somaliland-Ethiopia Boundary. Somewhat ironically the first demarcation of an Ethiopian boundary—that with British Somaliland—was completed on the eve of the Italo-Ethiopian war. The work of demarcation is described by Lieutenant Colonel E. H. M. Clifford, chief of the British Section of the Boundary Commission (*Geogr. Journ.*, Vol. 87, 1936, pp. 289–307). The commission was in the field three years (1932–1935) in a most trying country and achieved a success measured by its contribution both to knowledge and to human relationships. Colonel Clifford's observation that "the essence of the work of a boundary commission is the improvement of frontier relations" should be stressed. A prime difficulty of the British Somaliland–Ethiopia boundary is that it cuts across tribal grazing grounds in the Haud, a vast area of thornbush with permanent water at only two points. This problem has been met by the inclusion of a transfrontier grazing clause. In the Haud the line was marked by a lane cleared of bush for two meters on each side of the line and with boundary pillars not more than two kilometers apart. Northwest of the Haud, in undulating country with some cultivation, a system of short double ditches was used, and beyond, in the lava country, the boundary line was "scraped" on the bare boulder-strewn surface. A reconnaissance aerial survey proved invaluable to the ground surveyors.

ASIA

Some Recent Chinese Geographical Studies. Progress is being made in China in geography and tributary fields by such sources as the Institute of Meteorology, the several geological surveys, and the newly organized Geographical Society of China. Several of the following publications are in Chinese with an English summary.

The National Research Institute of Meteorology in Nanking (cf. *Geogr. Rev.*, Vol. 20, 1930, pp. 520–521) has now published several memoirs. In "Circulation of Atmosphere over China" (*Memoir No. 4*, 1934) Coching Chu points out that "there are four so called 'centers of action' which affect the air circulation over China, viz.,

the Siberian Anticyclone and Indian Low on the continent, and the North Pacific Anticyclone and Aleutian Low over the ocean. In winter the Siberian Anticyclone holds the sway, while in summer it is the Asiatic low pressure that dominates the situation, hence winds over China are off-shore in winter and on-shore in summer." Pilot-balloon soundings over Nanking show that the northeast monsoon is seldom more than 3000 meters in thickness but that the southeast monsoon occasionally reaches 5000 meters or more. *Memoir No. 5* (1935) is a study of "Some Regional Rainfall Types of China" by Chang-Wang Tu, in which the country is divided into 10 regions and 41 subdivisions. *Memoir No. 6* (1935) deals with "A Preliminary Analysis of the Air Masses over Eastern China" and is by Jeou-jang Jaw. Rainfall records for 352 stations have been collected and plotted on maps by Chu, Tu, and Chang in "The Chinese Rainfall" (Nanking, 1935).

"The Aridity of North China" is considered by two writers. In the *Journal of the North China Branch of the Royal Asiatic Society* (Vol. 63, 1932, pp. 65–80) Raymond T. Moyer examines the problem of desiccation and concludes that little change has occurred since at least the fifth century. Since the second century before Christ periods of enough rainfall have been interspersed with times of crop failure, but there is no evidence that droughts are becoming more frequent or severer. Under the same title Coching Chu examines rainfall variability and finds that it exceeds 20 per cent for most of North China (*Pacific Affairs*, Vol. 8, 1935, pp. 206–217). Chu quotes Biel as reporting that "in no other thickly populated part of the world is the amount of variability of rainfall so great as in North China."

Father Ernest Gherzi of the Jesuit Zikawei Observatory, Shanghai, has recently produced an "Atlas de l'humidité relative en Chine" (1934) and an "Atlas thermométrique de la Chine" (1934). The latter shows January absolute minima of −40° C. for Harbin, −10° C. for Shanghai, and 0° C. for Hong Kong. August maxima are 34° C. in Harbin, 39° C. in Shanghai, and 36° C. in Hong Kong. The central interior has maximum temperatures of 44° C.

Conspicuous progress is being made in the field of soil studies. Under the direction of the National Geological Survey excellent field work has been undertaken. *Soil Bulletin No. 6*, "A Reconnaissance Soil Survey of a Portion of Kwangtung Province," by Robert L. Pendleton (1933), is the most geographically useful account of the province available. Agriculture is discussed in detail, and there are 104 photographs. *Soil Bulletin No. 7*, "A Reconnaissance Investigation of the Saline Delta Soils of Eastern Kiangsu, China," by James Thorp and K. C. Hou (1934), was made primarily "as a general guide in the program of reclamation of these saline soils for the production of cotton and other crops." The same authors are responsible for the valuable report "Soils of Northern and Northwestern China," *Soil Bulletin No. 12* (1935). *Soil Bulletin No. 10*, "Soils of Shansi Province," by Raymond T. Moyer (1935), deals with the matter presented by Professor Moyer in this number of the *Geographical Review* (pp. 414–425). In 1935 James Thorp published a paper entitled "Geographic Distribution of the Important Soils of China," together with a map, in the *Bulletin of the Geological Society of China* (Vol. 14, 1935, pp. 119–160). The soils are also discussed, without the map, in the *Report of the Fifteenth Annual Meeting of the American Soil Survey Association* (*Bull. 16*, 1935, pp. 18–24). The map covers all of Greater China except Tibet and Outer Mongolia and shows the distribution of 9 pedalfers, 10 pedocals, and 2 alkali soils. The pedalfers are all in South China, i.e. below the Hwai River; the pedocals are in the North. Alkali soils are found along the sea near the mouths of the Hwang and the Yangtze and in Mongolia.

Agricultural studies of interest to geographers are being undertaken by the University of Nanking and the National Agricultural Research Bureau. Of special importance is C. C. Chang's "An Estimate of China's Farms and Crops," published by the University (1932), which gives the latest government statistics by provinces and products and plots them on 12 large maps.

An article (in Russian) on the "Plant Resources of China" has been contributed by V. P. Alekseev as Supplement 72 to the *Bulletin of Applied Botany, Genetics and Plant Breeding* (Leningrad, 1935). Several maps show the limits of various types of vegetation.

Geomorphic studies have long been given careful attention. Dr. George B. Barbour continues his contributions in "The Geomorphology of the Nanking Area" (*Natl. Research Inst. of Geol. Contrib. 3*, 1933, pp. 81–136), "Physiographic Stages of Central China" (*Bull. Geol. Soc. of China*, Vol. 13, 1933–1934, pp. 455–467), and "Physiographic History of the Yangtze" (*Natl. Geol. Survey of China Geol. Memoirs*, Ser. A, No. 14, 1935). In this last the various sections of the valley are considered in detail. The upper river has had a complex history of captures and mid-Tertiary faulting; the middle river is superimposed from an earlier-Tertiary peneplain; and the lower river is essentially consequent, following a line of depressions. In the *Geographical Journal* for July, 1935 (Vol. 86, pp. 54–64), Barbour summarizes recent studies on the loess of North China.

In addition to the publications mentioned in the note on Chinese cartography in the *Geographical Review* for July, 1934 (Vol. 24, pp. 497–498), reference should be made to the magnificent "A New Atlas of China" (1934) in 53 plates prepared by V. K. Ting and W. H. Wong (respectively past and present directors of the National Geological Survey of China) and S. Y. Tseng for the Shanghai newspaper *Shun Pao* to commemorate its sixtieth anniversary. This atlas is probably the best piece of Chinese cartography since the work of the Jesuits in the seventeenth century. The atlas is entirely in Chinese.

The problems that confront the student of Chinese geography are as much human as physical. An indication of the growing concern of Chinese scholars with the dangers of overpopulation is found in Yin-tang Chang's "The Seriousness of the Population Problem in China" (*Journ. Geogr. Soc. of China*, Vol. 1, No. 1, 1934, pp. 3–12). In the *Journal of the Geographical Society of China* (Vol. 2, No. 2, 1935) Huan Yong Hu considers "The Distribution of Population in China" and presents both an isopleth map and a dot map. On the basis of recent census returns for 25 provinces and the foreign leased areas and of older figures for the three other provinces and Mongolia and Tibet, Hu reports a population in the whole of China of 458,915,439 persons. Reference should also be made to the note "A Recent Study of the Farm Population of China" (see below).

Two nongeographical publications of interest to geographers are Herbert Chatley's "The Port of Shanghai," now in its eighth edition (Whangpoo Conservancy Board, *General Ser. No. 8*, 1934), and the *Annual Report* of the China International Famine Relief Commission, which has its headquarters in Peiping. The thirteenth report covers 1934 and describes the far-reaching results of the Commission's work on roads, irrigation, rural reconstruction, and disaster relief.

Several recent contributions deal with the larger geographical aspects of China. Professor Percy M. Roxby of Liverpool has written a thoughtful paper entitled "China as an Entity: The Comparison with Europe" (*Geography*, Vol. 19, 1934, pp. 1–20). In it he points out that China is not merely a geographical expression but a real and fundamental entity, one of the chief roots of civilization, in which the ancient cultural unity is being steadily quickened into a national self-consciousness that will eventually find full political expression. The time required for this political transition constitutes China's main hazard. Professor Heinrich Schmitthenner of Leipzig brings together his travel observations in "China im Profil" (Leipzig, 1934). Geographers will be especially interested in the first chapter, in which the author defines three main *Landschaften* that have influenced Chinese life—the Loessland, the North China Plain, and Middle and South China. In "An Attempt at a New Classification of the Natural Regions of China" (*Journ. Geogr. Soc. of China*, Vol. 1, No. 2, 1934, English abstract, pp. 1–3) Dr. F. Hung divides Greater China into the

Eastern Monsoon Region and the Central Asiatic Plateaus. The Eastern Monsoon Region is divided into 5 groups and 22 regions, several of which are subdivided.

GEORGE B. CRESSEY

A Recent Study of the Farm Population of China. It is a commonplace that we know less about the population of China than about that of any other important country. But, owing to the work of Professor J. Lossing Buck and collaborators, we now have a detailed analysis of a small but judiciously chosen sample of the Chinese farm population. "Chinese Farm Economy" (reviewed in the *Geogr. Rev.*, Vol. 21, 1931, p. 352) covered 2866 farms in seven provinces, with about 730 inhabitants to a square mile in the areas studied. This work has been continued since by Chi-Ming Chiao, a disciple of Professor Buck's, who has presented a report of the work from January, 1929, to February, 1931, in recent numbers of the quarterly of the Milbank Memorial Fund (A Study of the Chinese Population, *Quart. Bull.*, Vol. 11, No. 4, New York, 1933, *Quarterly*, Vol. 12, Nos. 1–3, 1934; also reprinted as a 56-page pamphlet, with a foreword by Edgar Sydenstricker). With several enumerators working under him, Chiao canvassed 12,456 farm families in 11 provinces.

The two main divisions, the North and the South, are recognized in the analyses of population, the Hwai River being taken as the dividing line. After the density of population perhaps the most important demographic factor is the percentage of adults, for most adults are breadwinners and most children are not. In the population studied this percentage was about 53.5 in the whole area, 55.4 in the North, and 52.0 in the South—figures not very different from those for the farm population of the United States at the same time.

A large proportion of adults generally means few children and a low birth rate, and vice versa; but in this case the accuracy of the returns, in a population unaccustomed to statistical inquiries, is, of course, questionable. Chiao's estimate of the birth rate is 36.6 a thousand for the whole population, 37.9 for the North, and 35.6 for the South —all rather high figures in spite of possible incompleteness.

The ratios of male to female births seem to be 1.104 in the whole area, 1.152 in the North, and 1.066 in the South. These ratios are rather high, and one might suspect that they are exaggerated owing to the well known Chinese prejudice against female infants; but they are confirmed fairly well by statistics from a few hospitals and other places where accurate records have been kept and also by the ratio of boys to girls in the Chinese population of the United States.

In the population studied there were about 9 per cent more males than females. The greatest excess of males, 28 per cent, was between the ages of 10 and 15. (Much the same state of affairs is also found in India and to a less extent in some primitive communities in North and South America and may be due in part to the early marriage of girls.) Above the age of 55 females were in the majority, as in most other countries. The average age of marriage was found to be 20.19 years for males and 18.82 for females. Early marriage for both sexes is commoner in the North than in the South.

A Chinese household is a rather different kind of organization from that which we are familiar with. It may include relatives of many kinds and other persons, such as fiancées; indeed, Chiao found more than 70 kinds of relatives in the families he studied. But the number in any one home is comparatively small, and the average number of persons found was 5.25 to a family and 5.43 to a household (North, 5.55 and 5.78; South, 5.03 and 5.18).

The death rate was estimated at 25.7 a thousand (North, 24.2; South, 26.8). The infant mortality was 15.7 per cent (North, 18.6; South, 13.2), about double that of Europe and the United States. The excess of births over deaths in normal times is about 1.09 per cent a year, which would double the population in 64 years (North, 51;

South, 79), if it were not for famines, floods, wars, etc., which have long served to keep the population of China nearly stationary. In Chiao's concluding words: "Frequent famine and other catastrophes seem to be the only way of relieving population pressure at present in China."

It is interesting to note that some of the differences found between the farmers of North and of South China are such as those who believe in the "enervating" effects of warm climates would expect and some are not.

ROLAND M. HARPER

PHYSICAL GEOGRAPHY

Microseisms and Meteorology. Since the time when, with the advent of the first sensitive seismograph, it was learned that the earth's surface is in a more or less constant state of slight tremor, the cause of microseisms has aroused the interest of seismologists, and many attempts have been made to explain them. Because of their much greater amplitude near the coast the view has long been held that they are set up by the surf. More recently barometric oscillations have been suggested as the cause. Evidence in favor of this theory is advanced by Donald C. Bradford, who has studied the relation between microseisms and pressure at St. Louis (Microseisms and Their Relationship to Changing Meteorological Conditions, *Bull. Seismol. Soc. of America*, Vol. 26, 1936, pp. 29–53). An item of special interest in his paper is the assignment of microseisms of different average amplitude to certain forms of the areas of low barometric pressure, even though the correlation is not in every case satisfactory.

Mr. Bradford's conclusion is that microseisms are under the direct influence of changing meteorological conditions. This carries with it the implication that they can be set up anywhere but that conditions are more favorable near the sea. It would seem accordingly that, if the surf beating on the shore cannot be accepted as the cause, the part of the continent near the coast can be more readily set into vibration. Detailed studies both in the interior and near the coast with adequate means of ascertaining the method of propagation would seem to be the most promising method of further attack.

N. H. HECK

Climatic Boundaries. With few exceptions, widely known and used classifications of climate have claimed validity for the boundaries of their climatic regions on the ground that these lines of division correspond to boundaries between vegetational formations. Protests have occasionally been uttered against this use of irrelevant sanctions for climatologic distinctions but have not themselves borne fruit in acceptable syntheses. Such classifications as Köppen's, which frankly abandon the attempt to find regional boundaries among the continuous gradations of the climatic elements, remain more satisfying than the efforts that have been made toward achieving regional distinctions on purely climatologic grounds. One reads with interest, therefore, a recent essay by Eduard Markus (Klimatische Grenzlinien, *Annalen der Hydrogr. und Marit. Meteorol.*, Vol. 63, 1935, pp. 144–155) in which the problem of rational definition of climatic boundaries is attacked afresh.

The central problem in any such effort is to find regional boundaries in observational data. Markus finds them in the narrow zones on isarithmic maps where a climatic element changes rapidly along the earth's surface, i.e. the zones identified by a close crowding of isarithms. A map of the distribution of a single element naturally yields only a few such boundaries. But by using January and July temperatures and annual precipitation Markus assembles a considerable number, which when plotted on a map provide the starting point of a full division of the earth into climatic regions. The regions finally arrived at resemble the large groups A, B, C, D, and E of Köppen's classification. Examination of Markus' map discloses, however, a difficulty

that could have been foreseen by looking up the occurrence of crowded isarithms on fairly large-scale maps of the climatic elements: zones of rapid change in the value of an element are limited in length, and boundaries drawn along them cannot be other than discontinuous. Even when all the pertinent elements are drawn on, these zones do not provide the complete division of the surface of the earth into regions that is sought. Markus overcomes the difficulty by filling in the gaps with boundaries drawn along arbitrarily selected isarithms. Such makeshift supplementary boundaries can claim no advantage over those used in the familiar classifications.

Discussion of regional climatic contrasts concerns itself either with the distribution of the climatic elements, conceived as physical quantities varying continuously over the earth's surface, or with attempts to distinguish climatic regions possessing homogeneity sufficient for the purposes aimed at in a classification. It is to be doubted whether the two viewpoints can be satisfactorily merged. A strictly physical climatology works best from isarithmic maps. The climatology of synthetic regional types has involved the tacit or explicit judgment of climate from biologic or other alien viewpoints or has been a pedagogic device. For the purposes of an applied climatology, no serious objection is to be urged against taking the criteria of classification from the phenomena that climatologic considerations are expected to elucidate. For such purposes, available classifications are to be preferred to Markus' system. His system may be of use as a preliminary orientation in a physical climatology, but the user must be on guard lest its partly fictitious boundaries obscure the fundamental quality of the distribution of the climatic elements, namely their continuous gradation.

JOHN LEIGHLY

Climatic Pulsations. An admirable article by Professor Ellsworth Huntington in the anniversary volume for Sven Hedin published by the Svenska Sällskapet för Antropologi och Geografi (Climatic Pulsations, *in* Hyllningsskrift tillägnad Sven Hedin på hans 70-årsdag den 19 febr. 1935, pp. 571–608, *Geografiska Annaler*, Vol. 17, 1935 [special number]) summarizes the evidence for climatic oscillations during historical time in a convincing way. Professor Huntington shows that instrumental meteorological observations of temperature and rainfall do not support the belief that climate is stable, demonstrating instead the existence of long-period fluctuations of appreciable magnitude. The longer the record, the larger the changes it shows, and this gives a prima-facie case for still greater fluctuations during the 6000 years of historical time. Thus the hundred-year temperature record at Philadelphia shows a slow variation equivalent to a change of latitude of about 3°; whereas the weather recorded by Claudius Ptolemaeus at Alexandria in Egypt in the first century of our era finds its present-day parallel 9° farther north. It is not unreasonable that the change in 1900 years should be three times that in 100 years.

The much-debated question of climatic change in Palestine is presented in a new and striking way. A map showing the distribution of known ruins and inhabited villages brings out very strongly the migration of the population toward the rainier north and west during the past two thousand years or so; and, when comparison is made with the orographical features, it becomes clear that the only possible explanation is a northward migration of the zone of rain-bearing westerly winds. Even the details in the history of Petra, Damascus, and Palmyra are shown to be necessary consequences of this gradual shift of climate and the changes that it caused in the trade routes between east and west. Syria and Palestine are well suited to the demonstration of such changes, because they lie on the borders of aridity in a zone where the variation of climate with latitude is unusually rapid; but similar evidence has been found in many other parts of the world. Unfortunately, most explorers in small regions, imbued with the idea of climatic stability, have attempted to account for the evidence by purely local causes, especially misgovernment and nomad raids; and

scientists in general have been curiously loath to accept the wider and simpler explanation of a change of climate. Moreover, the evidence is not only historical or archeological; one of the most widespread indications of climatic cycles is the existence of alluvial terraces in river valleys, and the sequence of these terraces shows a remarkable similarity in semiarid regions all over the world. It should be remarked, however, that the evidence of the terraces loses much of its value unless they can be accurately dated—a problem for archeologists. The recent work of Erik Granlund, for example, on the variations of rainfall shown by the peat bogs of Sweden (De svenska högmossarnas geologi, *Sveriges Geol. Undersökning*, Ser. C, No. 373, Stockholm, 1932) is a model of research into dated climatic changes.

Old beliefs die hard; but the evidence accumulated by Huntington and others during the present century from regions as diverse as Greenland and equatorial Africa leaves little room for doubt about the reality of climatic changes in historical times. For some parts of the world it is now possible to follow the course of these changes in broad outline over a period of two or three thousand years. Broad outline, however, is not enough; the next stage is to fill in all the details, and this is more than a one-man job. Even for any one country it will generally require a knowledge of history, archeology, geology, botany, meteorology, and other science rarely combined in a single individual; what is now required is teamwork. The subject is not merely academic; for if Huntington is right in his contention that industrial output, health, birth and death, and the fabric of civilization itself are all profoundly influenced by climatic fluctuations, these fluctuations achieve an outstanding practical importance and demand a corresponding common effort for their study.

C. E. P. Brooks

Bird Migration and Climatology. In his recent publication "The Migration of North American Birds" (*U. S. Dept. of Agric. Circular No. 363*, 1935) Frederick C. Lincoln sums up the available data on this fascinating topic. The Biological Survey, with the help of a great number of birdbanders, has been able to give us some indication of where the birds spend the winters and how fast they travel and something about the extent of their migration lanes. Many birds—for example, the tree sparrow and the junco—have short migration routes. Others travel from the Arctic to the Antarctic each year. The extreme summer and winter homes of that "champion 'globe trotter,' " the arctic tern, are 11,000 miles apart. "The longest flight known for an individual bird was accomplished by an arctic tern that in 3 months flew from the coast of Labrador to the coast of southeastern Africa." Some birds travel slowly, some rapidly. The Canada goose, hardy and well adapted to sudden and extreme cold for short periods, moves north early with the advance of spring—coincident with the advance of the isotherm of 35° F. On the arrival of the goose in northern Canada at the end of April it will experience for short periods severe drops in temperature that would exterminate less tolerant and more delicate birds. These low temperatures are not constant; and, when an average or mean is considered, it is seen that the Canada goose has been keeping pace with a mean set of climatological conditions that are favorable to it. On the other hand, slow migrators such as the cliff swallow move more rapidly along the Pacific coast than along the Atlantic coast as they advance up the North American continent because of the average higher temperatures that prevail on the Pacific side. The western tanager also illustrates how the birds along the Pacific coast migrate faster than the eastern birds. The gray-cheeked thrush is a very rapid migrant. Apparently it remains in the lower Mississippi Valley until the season has advanced far to the north. Then, by rapid flights, it moves northward and arrives at its breeding grounds on time. There must be a reason for this variation.

Mr. Lincoln's maps show migration routes and rates and winter and breeding areas

of several species, but the types of winter habitat are not indicated. The breeding range of the scarlet tanager lies well within the limits of the deciduous forest. Its winter home as indicated by Figure 17 comprises the west half of Colombia, all of Ecuador, and the north half of Peru. There a number of different vegetational regions—from tropical grassland, alpine grassland, and tropical desert to tropical rain forest and broad-leaved evergreen forest—are found. Certainly the scarlet tanager is not found in all these zones. From an ecological viewpoint a clearer description of the winter and summer ranges of the migratory birds is called for.

This whole problem of migration routes and breeding and winter ranges is due to a combination of various environmental factors that include climatological, physiographical, food, and cover relationships, all of which bring about physiological reactions peculiar to the species. Various combinations of these factors may then have very definite limiting effects on the ranges and routes of migratory birds. The reviewer (Climographic Studies of Certain Introduced and Migratory Birds, *Ecology*, Vol. 17, 1936, pp. 122–132) has shown a correlation of the mean monthly temperatures and humidities for breeding and winter ranges of each of several migratory birds. It seems evident that each species has an optimum set of temperature and humidity relations that are suited to its physiological requirements. It is true that many of the migratory birds have very wide ranges, but that is due possibly to the fact that they have a greater range of adaptability to two factors—temperature and humidity. No doubt many other factors enter in.

ARTHUR C. TWOMEY

HUMAN GEOGRAPHY

Nebraskan Sugar and the World Sugar Problem. Colorado leads the states of the Union in the production of sugar beets, with an annual average of about 2,365,000 tons (1923–1932). Nebraska ranks second with a corresponding production of about 932,000 tons. In a recent publication entitled "The Sugar Beet Industry of Nebraska" Professor Esther S. Anderson describes sugar production in that state and presents many data concerning the industry as a whole in its technical, social, and economic aspects (*Univ. of Nebraska, Conservation and Survey Division, Conservation Dept. Bull. 9*, Lincoln, 1935). In dealing with the relation of the physical environment to the growth of sugar beets she states a general principle: "The sugar content in beets grown in the semiarid Great Plains usually varies inversely with the summer temperature and the total rainfall in autumn, especially in October and November. . . . Experiments made in Europe seem to prove that a cool climate with long summer days is a more important factor in beet growth than is the soil." Although "the yield of beets is generally lower in the areas of many hours of daylight . . . this is offset by a higher sucrose content." The greater part of the sugar-beet crop in the United States is grown under irrigation. Beet-sugar factories are usually near the beet fields. "Since the beets are bulky and perishable, they cannot be transported economically for great distances." Coal equal to only "12 or 13 per cent of the weight of beets . . . is necessary in the operation of a factory." Hence it is cheaper to bring the coal to the beets than the reverse.

In the *Harvard Business Review* (Vol. 14, 1935–1936, pp. 172–185) Professor J. E. Dalton, formerly chief of the Sugar Section of the Agricultural Adjustment Administration, presents in favorable light the recent efforts of the United States government to find a solution of the problem of an oversupply of sugar. Without going into the controversial aspects of this subject, two or three points of general interest may be mentioned. In 1932 the supplies of sugar received in the United States from the Philippines were more than fourfold those of 1923, from Puerto Rico threefold, and from Hawaii nearly double; from Cuba only a little more than half as much was received. The increase in the production of sugar in Puerto Rico and the Philippines

resulted almost wholly from improvements in technical methods rather than from expansion of the acreage under cultivation. Professor Dalton states that "wide currency has been given to the opinion that production control is impossible, or at least ineffective, due to the wide and unpredictable variation in growing conditions, *e.g.*, drought." Among reasons for doubting this, he points out that "the main producing areas of sugar cane and sugar beets for the American market are so widely scattered . . . that any act of God, such as drought or hurricanes, would not have the effect of reducing generally the total amount of sugar available for the American market on a yearly basis. Consequently the drought in the beet area in the fall of 1934 did not jeopardize the supply of sugar in the United States in 1935."

Manioc. In small interior cities of Brazil it is interesting to meet at table what looks like boiled turnips and turns out to be *manioca*, tasting remarkably like Irish potatoes. Roy Nash, in "The Conquest of Brazil," describes the plant and gives it high place among Brazilian native foods, praising its unique quality of self-storage —it "keeps" in the ground until required! In some 50 well packed pages Walter Kiok widens the picture of this useful plant (Der Maniok: Ein Beitrag zur Wirtschaftsgeographie der warmen Länder, Greifswald, 1934). Native to Brazil and tied to the low tropics by its need of 8 to 18 months for growth, it has now spread all over the tropics, just as the Irish potato has spread all over the temperate zones. Now the manioc, like the potato, is grown on a far larger scale in the Old World than in the New. Four-fifths of the acreage is in Java and Madura (1,764,000 acres), Madagascar (780,000 acres), and Brazil (721,000 acres). These three regions produce 5½, 3⅓, and 2⅒ million tons respectively of manioc roots. The plant is known in Spanish-speaking countries as yuca and elsewhere as cassava. In 1932 France was importing large quantities from Madagascar and French West Africa as a substitute for wheat in bread. In the East manioc is grown on high ground that cannot be irrigated for rice or among the rubber plants while they are growing up to bearing age. In both Java and Madagascar it seems to be grown largely by natives—not Europeans—and is now almost as important a food as rice.

Brazil exports less than 1 per cent of its crop, but a quarter of a million tons in a total that may perhaps reach 15 million tons is exported from Madagascar and Java. Exports are chiefly to the United States, as tapioca, to England, and to France, but as manioc it is unfamiliar even to these lands, which are using a quarter of a million tons a year.

MARK JEFFERSON

GEOGRAPHICAL REVIEWS

Reports of the "Meteor" Expedition

Georg Wüst. **Das ozeanographische Beobachtungsmaterial (Serienmessungen).** vii and 290 pp.; diagrs. (Wissenschaftliche Ergebnisse der Deutschen Atlantischen Expedition auf dem Forschungs- und Vermessungsschiff "Meteor" 1925–1927, Vol. 4, Part 2.) Walter de Gruyter & Co., Berlin and Leipzig, 1932. 11½ x 9 inches.

Theodor Stocks and Georg Wüst. **Morphologie des Atlantischen Ozeans,** Part 1: **Die Tiefenverhältnisse des offenen Atlantischen Ozeans: Begleitworte zur Übersichtskarte 1 : 20 Mill.** 32 pp.; maps, diagrs. (*Ibid.*, Vol. 3, Part 1.) 1935.

Georg Wüst. **Schichtung und Zirkulation des Atlantischen Ozeans,** Part 2: **Die Stratosphäre.** iv and 180 pp.; maps, diagrs. (*Ibid.*, Vol. 6, Part 1.) 1935. 11 x 8½ inches.

Ernst Hentschel. **Die biologischen Methoden und das biologische Beobachtungsmaterial der "Meteor"-Expedition.** vi and 274 pp.; maps, diagrs., ills. (*Ibid.*, Vol. 10.) 1932. 11½ x 9 inches.

Ernst Hentschel. **Allgemeine Biologie des Südatlantischen Ozeans,** Part 1: **Das Pelagial der obersten Wasserschicht.** 168 pp.; maps, diagrs., ill., bibliogr. (*Ibid.*, Vol. 11.) 1933.

The results of this great oceanographic expedition are steadily making their appearance (cf. H. A. Marmer: Recent Major Oceanographic Expeditions: A Review of the Work of the Meteor, Carnegie, Dana, and Snellius Expeditions, *Geogr. Rev.*, Vol. 23, 1933, pp. 299–305). The oceanographic observations obtained on the *Meteor* expedition in 1925–1927, principally in the South Atlantic, have been checked carefully and obvious inaccuracies discarded. The expenditure of effort and critical foresight in the reduction, preparation, and presentation of this material is highly commendable. The report under review includes: (1) a brief discussion of the methods used in reducing and checking the observational data; (2) tables of oceanographic serial measurements, containing temperature, chlorinity, salinity, and density values and supplementary information, from 310 stations, in 14 profiles; (3) tables of temperature, salinity, and density interpolations for standard depths at all stations; (4) an appendix for oceanographic results from the three stations of the preliminary trial expedition.

H. R. Seiwell

The soundings from which the new bathymetric chart of the Atlantic Ocean was constructed were accumulated over a number of years. The chart is the most complete compilation of existing data available at present. For the North Atlantic the soundings were obtained by many different ships; for the South Atlantic the most of them were obtained by the *Meteor* (see also Theodor Stocks: Die Fortschritte in der Erforschung des Atlantischen Ozeans 1854–1934, *Geogr. Zeitschr.*, Vol. 42, 1936, pp. 161–171).

In all, 13 traverses were run between South America and Africa. Profiles were constructed from the echo soundings, which give a clear picture of the morphology of the sea floor between the two continents. The authors are careful to point out that the new data merely add to preëxisting knowledge. They have been enabled to delimit with greater precision and accuracy features whose broad outlines had, in large measure, previously been known. It must be remembered that even now only the gross relief can be delineated.

The ocean is divided into an eastern trough and a western trough on the basis

of the mid-Atlantic ridge. These two troughs are subdivided from north to south into basins and sills. Particular attention was paid to the configuration of the peaks and the plateau summits of the mid-Atlantic ridge and to the transverse sills that separate the basins. The floors of the basins were found to possess greater diversity of relief than had formerly been supposed. The Romanche Channel, which cuts the mid-Atlantic ridge at the equator, has been recharted in considerable detail.

H. C. STETSON

Owing largely to the work of the *Meteor* expedition, the internal structure of the waters of the South Atlantic is no longer a matter of speculation. As the result of more recent work by other expeditions in the North Atlantic a sufficient number of reliable subsurface temperature, salinity, and oxygen observations are now available to make it possible to examine with considerable assurance the interrelation of the waters of the two oceans. Since 1922 Dr. Wüst has been especially concerned with the slow, deeper, north-south movements of the ocean stratosphere, as the great mass of relatively cold deeper waters is now called. Thus he is especially qualified to present an exhaustive study of the internal stratification and circulation of the whole Atlantic in the light of modern findings.

Wüst's earlier findings have been on the whole fully confirmed by modern data. Through a study of the distribution of oxygen he has been able more fully to define and to subdivide the deep, longitudinal movements. Also he is now able to trace the influence of the primary masses of water over much greater distances than in his earlier papers. This is especially true of the outflow of relatively saline water at mid-depths from the Strait of Gibraltar, which is now shown to exert a considerable influence as far west as Bermuda and also to supply much of the salt for the mid-depths (1500–2700 meters) of the South Atlantic.

It is possible in this review only to summarize the broader aspects of Wüst's researches. If the surface layer of the ocean having temperatures higher than 8° C. is disregarded, three main north-south movements are found below the equator.

1. A relatively fresh layer centering at 750 meters has a northerly component. This layer originates at the surface in high southern latitudes (latitude 50° S.) and can be traced as a layer of minimum salinity everywhere north of this latitude as far as 22° N.

2. Next to the bottom a very cold, fresh layer is also spreading northward. This water receives its characteristics at the surface near the coast of the Antarctic Continent.

3. The mid-depths (1500–3500 meters) are occupied by a southward-moving layer of relatively saline water. This contribution from the North Atlantic has been shown by Wüst to have three principal axes of flow, originating at considerable depths in the north and converging and approaching the surface in the far south.

The northern production of bottom water is relatively weak, as is also the northern counterpart of the intermediate layer of low salinity.

C. ISELIN

In contrast with the biological work of the earlier oceanographic expeditions, which were more concerned with systematic accounts of the plankton, the *Meteor* expedition planned to stress the biology of the sea as such. To this end, a quantitative rather than a qualitative investigation, particularly of the nannoplankton (microplankton) in the upper 50 meters, was undertaken for comparison with hydrographic observations.

The first of the two biological volumes here reviewed consists chiefly of descriptions of the methods used, together with station lists, counts of the various organisms, and daily lists of animals seen at the surface (whales, flying fish, *Physalia*, etc.) and of the birds following the ship.

The second volume deals with the distribution of these forms, especially the

diatoms, coccoliths, peridinians, and protozoans from the surface layers. The plankton as a whole was concentrated south of 45° S., along the African coast from Cape Town to São Paulo de Loanda, and between the Senegalese coast and the Cape Verde Islands. This, by and large, is parallel to the distribution of phosphate in the upper 50 meters. Further analysis of the ranges of the four divisions of the nannoplankton with respect to one another and their absolute abundance revealed a slightly different range for each group. Although nutrients were the primary limiting factor, other factors were involved in some cases. The diatoms were apparently entirely limited by their nutrient supply, temperature, for instance, being ineffective, since they throve as far south as the ice. The peridinians, on the other hand, showed dependence on temperature. The protozoans were at a maximum off the La Plata and the Cape of Good Hope, in areas somewhat deficient in plant nutrients. The coccoliths, practically absent on the southernmost profile, just south of their area of maximum abundance (45°–50° S.), were apparently sensitive to temperature. Also, they were in general relatively more abundant along the outer borders of plankton-rich areas shunning coastal waters—an indication of an unknown influence detrimental to them near the coast.

The abundance of the metazoan plankton was roughly parallel to that of the nannoplankton. The regions of nannoplankton maxima along the coast of Africa were represented by similar maxima of zoöplankton, in many places somewhat farther out to sea or to the north on account of the transport of nutrients by the water masses. In addition, there were maxima off the mouth of the La Plata, the Niger, and other large streams, even off numerous bays and harbors. Obviously, other factors emanating from the coast also limited the abundance of the zoöplankton.

Despite this evidence, the author, in an introductory discussion of a paper on neritic communities to appear later, suggests that nutrient material from the land may not be so important for plankton production as was formerly supposed. He cites the fact that from Cape Town to Great Fish Bay the rich zone of nannoplankton along the west coast of Africa was off a more or less desert region. Also, off certain oceanic islands, such as St. Helena, where the planktonic species were typically oceanic, there was not an especially rich plankton production. Furthermore, where there was an abundance off river mouths, etc., it was mostly due to a swarm of one particular neritic species, which were not apparently regarded as a significant part of the plankton in the sea as a whole.

M. SEARS

WATER CONTROL AND FLOODS OF THE UNITED STATES

CLARENCE S. JARVIS AND OTHERS. **Floods in the United States: Magnitude and Frequency.** 497 pp.; maps, diagrs., bibliogr., index. *U. S. Geol. Survey Water-Supply Paper 771.* 1936. $1.00. 9 x 6 inches.

W. G. HOYT AND OTHERS. **Studies of Relations of Rainfall and Run-Off in the United States.** 301 pp.; maps, diagrs., bibliogr., index. *Ibid., 772,* 1936. $.25. 9 x 6 inches.

Although records of the daily flow for 20 years or longer were available for more than 225 rivers in the United States, this information was not assembled under one title in a form that could be used by the Water Planning Committee of the National Resources Board in planning public-works projects involving river control and use. This compilation has been completed by the United States Geological Survey and published as *Water-Supply Paper 771.* The report contains data on floods of the 225 rivers and on the volume of the momentary flood peaks and other flow characteristics (maximum discharge in a calendar day, maximum discharge in 24 hours, and percentage of the momentary flood peak in excess of maximum calendar-day average).

Various methods for estimating floods, examples of procedure for analyzing flood flows, and chapters on "Methods of Estimating Flood Flows Applied to the Tennessee River," by Thorndike Saville, "The Reliability of Statistical Methods in the Determination of Flood Frequencies," by J. J. Slade, Jr., and "Hydrologic Conditions as Affecting the Results of the Application of Methods of Frequency Analysis to Flood Records," by R. E. Horton, enhance the lasting value of this excellent compilation.

The Water Planning Committee found it necessary to know the relation of rainfall and related factors to runoff. This study was also made by the Geological Survey, and the results have been published as *Water-Supply Paper 772*. In consideration of previous studies on this topic this paper is confined to "(1) investigation of relations between annual and monthly precipitation, temperature, evaporation, transpiration, direct surface run-off, ground-water run-off, and infiltration as a basis for the quantitative analysis of the hydrologic cycle over broad areas and of trends and changes therein; (2) investigation of relations between storm precipitation and direct surface run-off." Numerous maps and graphs illustrate the maximum and minimum precipitation for one year and for a period of years for many Weather Bureau stations. Graphs of the mean annual temperature are employed to show changes of temperature. Relations between rainfall and runoff and the unit-hydrograph analysis of surface runoff are graphed for many streams.

The report by the Advisory Committee of the Section of Hydrology of the American Geophysical Union to the Water Planning Committee (included as an appendix) calls attention to the resolution of April, 1935, pointing out the necessity of "a permanent agency with authority to direct and correlate the work of all these separate agencies engaged in matters pertaining to the utilization of the nation's water resources." This same plea is the subject of a short report, "Drainage Policy and Projects," by a Special Sub-Committee of the Water Resources Committee of the National Resources Committee (1936). The report recommends a joint advisory committee consisting of one representative from each of the bureaus of Biological Survey, Agricultural Engineering, Entomology and Plant Quarantine, Reclamation, Public Health Service, and Fisheries, the War Department, and the Works Progress Administration, to be presided over by a nonfederal consultant appointed by the Water Resources Committee.

PHIL E. CHURCH

THE VOTE IN RECENT PRESIDENTIAL ELECTIONS

EDGAR EUGENE ROBINSON. **The Presidential Vote, 1896–1932.** ix and 403 pp.; maps. Stanford University Press, Stanford University, Cal.; Oxford University Press, London, 1934. $6.00. 10 x 8 inches.

The main purpose of this substantial book is to make "available for the first time a full statement of the presidential election returns" for the period 1896–1932. The greater part of the volume consists of tables of statistics showing the vote and its distribution. "This is the historical record. Others will use it as their interests and methods dictate." The fundamental table, which fills 246 pages, presents for each election four items concerning the party vote for presidential electors in every state and county in the United States: the total vote, the Republican vote, the Democratic vote, and the vote for all other parties combined. Other tables give the vote by sections, the number of Republican, Democratic, and "other" counties, the party that led the poll in each county, etc. Ten maps in black and white show the counties carried by Republicans, Democrats, and "others." These maps, based on official returns, differ in some unimportant particulars from the corresponding maps, based in part on unofficial returns, in C. O. Paullin's "Atlas of the Historical Geography of the United States" (Carnegie Institution of Washington and American Geographical Society, 1932).

In the text certain facts and conclusions of general interest are stated, though no attempt is made at detailed interpretation. Six states were carried by the Democrats and one state by the Republicans at all ten of the elections of the period. Relatively "few counties have maintained a one-party lead in every election. The 619 counties that always gave a Democratic lead are found in twenty-one states. There are only 83 counties that invariably gave a Republican lead . . . , and these are distributed in twenty states." Hence "it is clear that the fighting territory at some time in this period has included most of the counties in the country (that is, in 2,394 out of a total of 3,096 in 1932)." Professor Robinson points out that the ordinary cartogram representing such distribution may be misleading. Not only are small counties in the densely populated parts of the country (as the counties in New York City) lost sight of, but the maps fail to show the strength of the vote for minority candidates in any county. It may be of interest to note that three large colored maps in "Scribner's Statistical Atlas of the United States" (New York, ca. 1892) indicate by ingeniously graded tints the percentage of the total vote in each county cast for the leading party in the elections of 1880, 1884, and 1888. Similar maps for the recent elections could readily be compiled from the statistics in the volume under review.

Professor Robinson writes: "In the face of these returns it can no longer be asserted with any degree of finality that sectional interests are paramount in the minds of the voters. . . . When the search works down to the counties it is increasingly clear that all generalizations as to predominant sectional interests must give way before the fact that every section has its minority—sometimes very small, but always there. It is clear also that the nation, as a whole, has waves of sentiment, resentment, conviction, that transcend sectional lines." Although we may agree heartily with the last statement, the fact that every section and every county have their minorities is hardly an argument against the reality of a considerable degree of consistency in the voting habits prevailing in different regions. A wave of political sentiment may break over the Solid South, as in 1928, or over the strongholds of Republicanism, as in 1932, but every campaign manager knows that the "solid" areas, large and small, usually tend to re-form again after they have been temporarily shattered. They are indeed important realities in the geography of American political life, just as the areas of consistent party instability are (see J. K. Wright: Voting Habits in the United States: A Note on Two Maps, *Geogr. Rev.*, Vol. 22, 1932, pp. 666–672). Doubtless Professor Robinson would be the last to deny this, but some unwary readers may be led to misinterpret the wording of his remarks about sectional interests quoted above.

Natural Regions of the Iberian Peninsula

Eduardo Hernández-Pacheco. **Síntesis fisiográfica y geológica de España.** Vol. 1, 258 pp.; Vol. 2, pp. 259–584; maps, diagrs., ills. *Trab. Museo Nacl. de Cienc. Nat., Ser. Geol. No. 38*, Madrid, 1934. 9½ x 6½ inches.

These two volumes constitute a generalized but inclusive report on the natural regions of the Iberian Peninsula. The study is introduced by a series of general chapters on geology, physical geography, climate, and vegetation. The mountain systems are discussed from the viewpoint of the Spanish school, the older mountains such as the Sierra Nevada being considered autochthonous, independent of movements that affected the African massif. The body of the work is given over to a discussion of "geographical-geological elements" of the peninsula organized under four main headings: (1) the Spanish massif, (2) the mountains surrounding the massif, (3) the outlying plains, and (4) the peripheral mountains. It might well have been titled "Natural Regions," which is the heading for the following chapter; for it discusses not only the physical and geological aspects of each of the subdivisions of

the chief regions but also, to a less extent, their climate and agriculture and the distribution of the people. Appendixes deal with the natural conditions in relation to the agrarian problem and with some special regional problems.

The discussion is in terms sufficiently generalized to allow its being followed conveniently on a small-scale map. The numerous photographs illustrating the various regions discussed in the text are excellent. The study suffers in the lack of a detailed index by which to locate the topics easily. The chief criticism, however, is one anticipated by the author: bibliographical references are, with few exceptions, omitted. A rather complete abstract of the contents of these two volumes may be found in a recent review by Jean Sermet (*Rev. Géogr. des Pyrénées et du Sud-Ouest*, Vol. 6, 1935, pp. 357–379).

College Textbooks on the Geography of Europe

Samuel van Valkenburg and Ellsworth Huntington. **Europe.** x and 651 pp.; maps, diagrs., bibliogrs., index. John Wiley & Sons, New York; Chapman & Hall, London, 1935. $4.50. 9 x 6 inches.

J. F. Bogardus. **Europe: A Geographical Survey.** xiii and 713 pp.; maps, diagrs., ills., bibliogrs., indexes. Harper & Brothers, New York and London, 1934. $4.00. 9½ x 6½ inches.

Raoul Blanchard and Raymond E. Crist. **A Geography of Europe.** xvii and 490 pp.; maps, diagrs., ills., bibliogr., index. Henry Holt & Co., New York, 1935. $3.50. 9 x 6 inches.

Margaret Reid Shackleton. **Europe: A Regional Geography.** xvi and 430 pp.; maps, diagrs., ills., bibliogrs., index. (The University Geographical Ser.) Longmans, Green & Co., London, New York, Toronto, 1934. $6.00. 9 x 6 inches.

Certain leading ideas, reiterated from time to time like leitmotivs in a Wagnerian opera, give structure and unity to Van Valkenburg and Huntington's "Europe." "The lack of storms and consequently of atmospheric variability as well as humidity join with the high summer temperature and dustiness to make the deathrate in Greece about 50 per cent greater than in Norway. The energy of the people shows a corresponding difference. This accentuates such matters as the tendency of the Greeks to talk politics while the Norwegians are developing power plants." This passage is a variation on the principal leitmotiv, introduced earlier in the book: "The dominance of Europe depends more upon climate than upon any other geographic factor." Climate and relief together "largely determine man's mode of life and the kind of crops he can raise. More than this, they greatly influence his philosophy and cultural outlook."

A map (which lacks, however, any explanation of its symbols) shows gradations in "climatic efficiency." It is "based on studies of the amount and quality of work, both mental and physical, which is done under various conditions of weather. Since . . . [this] is a purely physical map it cannot possibly be influenced by man's activities." The pattern on the map is very much like that on another map, which shows "cultural zones" based on "numerous factors of wide diversity," including "personal knowledge and observations." As the resemblance between the two maps can hardly be accidental, it "must mean that climate is a major factor in determining the location and shape of the zones." Q.E.D.

Three cultural zones are distinguished, A, B, and C, their boundaries forming roughly concentric circles around the North Sea. England, eastern Ireland, most of Scotland, France, Central Europe, and Scandinavia, and northern Italy lie in the A zone; Portugal, most of Spain, southern Italy, Russia, and southeastern Europe

in the C zone. Between the A and C zones is a narrow B zone. The scheme is ingenious and reflects to some extent the distribution of cultural levels in Europe.

A secondary theme is the "Natural Selection Motive." The hardships suffered by a people in the course of long migrations tend to weed out the inefficient. This, it is asserted, is an important reason why northern Italy is progressive and receives an "A" whereas southern Italy and Sicily are backward and receive only a "C." "In the north for two thousand years or more there has been a repeated influx of virile immigrants . . . In the south the same human stock has persisted for hundreds or even thousands of years." The reader would feel more comfortable if unimpeachable proof of these statements were given. Natural selection also offers a convenient explanation of the presence of "Grade A" people like the Dutch and the Swiss amid harsh and unpropitious natural environments.

"Although geographic factors are fundamental," Van Valkenburg and Huntington admit, "their effect is often diminished, and perhaps even neutralized, where people have sufficient innate ability, training, or outside help so that they can create the proper economic and political situation." This seems somewhat discordant, a theme that does not harmonize with the deterministic leitmotiv so confidently sounded elsewhere. Our authors even go so far as to concede that "the sensational economic development of Germany after 1870 . . . was proof that national progress rests on human qualities as well as on such physical factors as relief, soil, climate, and minerals." Proof, needed in regard to certain other matters, hardly seems required in this particular case.

In Bogardus' volume we hear echoes of the same climatic themes, but they are not played in such clarion tones. One cannot but feel, moreover, that this author has tried to cover too much ground. Had he devoted more attention to fewer topics, his book would have been less encyclopedic and, perhaps, more stimulating. We are told, for example, that the people of the Irish Free State differ from those of Great Britain and Northern Ireland in "race, culture and religion," but how they differ in these not unimportant respects is left to the reader's imagination. Would it not have been better either to describe Ireland adequately or to leave it out altogether? Reminiscent of one of the passages quoted above from Van Valkenburg and Huntington is the observation that "the human element in Europe in part explains its cultural progress. However, physical factors also are in part responsible." In the spelling of the names of towns, rivers, and islands Bogardus, like Blanchard and Visher in their "Economic Geography of Europe" (see *Geogr. Rev.*, Vol. 22, 1932, pp. 171–173), follows the official spellings used in the nations where these features occur. The present reviewer confesses irritation at seeing "Roma" for Rome, "Athēnai" for Athens, "Krētē" for Crete, "Peiraievs" for Piraeus, and "Wista" for Vistula (the last, which is often repeated, being due to a misreading of the Polish "Wisła"). For the sake of consistency Corfu should have been "Kerkyra," Thebes "Thēbai," etc.

Blanchard and Crist's shorter volume follows the tradition of the French school of descriptive regional geography. Much more space, relatively, is given to detailed accounts of natural and human regions within the countries and less to general descriptive matter than in the two volumes that have just been discussed. The senior author is the energetic and capable professor of geography at the University of Grenoble. Rather more knowledge of geology and of physiographic processes is assumed than the average beginner in the study of Europe is likely to possess. Unfortunately what would otherwise be an admirable book has been marred by not altogether skillful translation and by lack of thorough revision. The text contains a good many obscure passages and not a few misprints.

Miss Shackleton, like Blanchard and Crist, believes that knowledge of physiographic structure and form is fundamental in geography. Her well written and well illustrated volume is essentially a description of the physiographic regions into which

the European countries may be divided, with supplementary information on population and economic activities. Little is made of political and social matters. The book does not cover the British Isles.

No one of these books wholly corresponds to what one might conceive as the ideal in a college textbook on the geography of Europe, i.e. a textbook in which sound scholarship is combined with brilliance of literary style; in which the mere encyclopedic listing of facts is avoided; in which the author is not afraid to state general principles but does so in convincing terms and with the support of evidence above reproach; and in which due attention is devoted not only to physical and economic factors but also to the complex interrelationships between these factors and the political and social conditions that are of such immense importance in the Europe of today. Perhaps such a book will never be written; until it is, no teacher can well afford to base his course on Europe exclusively on the study of any one of the texts now available.

Historical Geography of Europe

Gordon East. **An Historical Geography of Europe.** xx and 480 pp.; maps, bibliogr., index. Methuen & Co. Ltd., London, 1935. 15s. 9 x 6 inches.

East's scholarly volume deals with a subject that, unfortunately, falls outside the scope of most courses of instruction as now organized. In the preface the writer says that in his opinion "it is necessary to substitute for the pursuit of wide generalization the careful study of particular illustrative cases. The following chapters, therefore, . . . seek, so far as is possible within a general survey, to focus attention on concrete instances of the activity of human societies in relation to their habitats." East practices in the body of his book what he preaches in his preface. He confines himself strictly to the evidence and does not allow his fancy to play with theories of geographical determinism and climatic control. "The historical geography of Europe," according to his definition, "is its human geography at the successive stages of civilization through which it has passed, and its human geography in turn is the expression on the face of Europe of the efforts of human societies to mould and adapt the countryside to their use." The period from the establishment of the Roman Empire to about the year 1870 is covered. No attempt is made, and wisely so, to treat the whole of an enormous subject in a systematic and comprehensive manner, and East admits that his book is "introductory and selective." Three main topics are considered: (1) the geography of settlement, both urban and rural, during the period of the Roman Empire and the Middle Ages; (2) the territorial evolution of certain European states; and (3) various phases of economic development. East's volume, an original contribution to historical and geographical method, ought not, perhaps, to be classed as a textbook, though parts of it could be used to great advantage as supplementary reading in a course on modern Europe.

Problems of Alpine Structure

E. B. Bailey. **Tectonic Essays, Mainly Alpine.** xii and 200 pp.; maps, diagrs., ills., bibliogrs., index. Clarendon Press, Oxford; Oxford University Press, New York, 1935. $4.25. 9½ x 6½ inches.

The Alps, rising in the midst of populous countries that long have fostered culture naturally have been scrutinized with unusual care and appreciation. Landscape features are open to free inspection, and Alpine scenery long ago gained world-wide fame. Structure of the bedrock is a far more obscure and difficult subject of study. However, many of the pioneers and outstanding workers in the comparatively young science of tectonics have devoted their lives to deciphering the complex framework of the Alps. Among geologists, Alpine structure has become as classic as Alpine scenery.

Unfortunately there is no comprehensive up-to-date work in English describing and explaining the chief tectonic units of the Alps and their relation to one another. It is extremely difficult for the average student to appraise the voluminous literature available, written chiefly in German and French by several generations of workers. Collet's book, "The Structure of the Alps" (London, 1927), is valuable; but it is encyclopedic in style, and it fails to clarify some matters, partly because it lacks adequate maps. Obviously Professor Bailey appreciates fully the difficulties experienced by "outsiders in Alpine tectonics," in which family he somewhat modestly claims membership. At least he has visited critical areas with competent students of tectonics as guides, and during many years he has studied with understanding the significant tectonic literature, from the brief but remarkable contributions of the pioneer Escher von der Linth to Heim's final monumental work, "Geologie der Schweiz."

The book does not pretend to be a complete treatise on Alpine structure; it is a series of essays, each dealing with a major problem whose solution has required the cumulative efforts of many workers. Glarus, the Prealps, the high limestone Alps of the Rhone sector, the Pennine Alps, and the window of the Hohe Tauern are discussed in successive chapters, illustrated by excellent maps. Probably most readers will wish for additional cross sections, and particularly for one or more to accompany Plate 1, showing the general relationship of the several nappes. The essays dealing directly with the Alps are followed by two on closely related subjects. One of these, entitled "Marcel Bertrand in Provence," contains abstracts of numerous significant papers by the great French geologist. The final essay describes the nappe structure near Gavarnie in the Pyrenees.

Each chapter ends with a selected list of references to the most pertinent literature. Readers who already have a general knowledge of Alpine structure will find the book a mine of supplemental information. On the other hand, beginners in this fascinating field can do no better than to use the book as their guide. We need more essays written in Bailey's straightforward, lucid style and with his sympathetic appreciation of the men whose labors have made possible an exposition of marvelously complicated mountain structure.

CHESTER R. LONGWELL

UGANDA AND KENYA

H. B. THOMAS AND ROBERT SCOTT. **Uganda.** xx and 559 pp.; maps, ills., bibliogr., index. Oxford University Press, London, New York, etc., 1935. $5.00. 9 x 6 inches.

L. S. B. LEAKEY. **Kenya: Contrasts and Problems.** xiii and 189 pp.; map, ills. Methuen & Co., London, 1936. 7s. 6d. 7½ x 5 inches.

"Uganda" is described as the successor to the official "Handbook of Uganda" (1913 and 1920), though it is not an official publication. Its authors had access to government records, and the then governor of the protectorate, Sir Bernard H. Bourdillon, wrote the introduction and Lord Lugard a foreword. The freedom from official constraint has, however, been used with discretion, and, although unusually readable, "Uganda" follows conventional arrangement. Its store of information is vast, and reference usage has proved its merits. Two exceptional features are the well chosen illustrations and the attractive maps, which include a dot map of distribution of native population (1 dot equals 1000 persons), by S. J. K. Baker. Four chapters are expressly devoted to the interest of the visitor to Uganda, and the chapter on native life may be singled out for special mention.

Dr. Leakey has turned aside from his studies in East African prehistory to give a picture of living Kenya in a remarkable little book. "I was born and bred in Kenya, and I have spent the greater part of my life there. . . . Kikuyu . . . became

almost my native tongue. . . . I am a member of the Mukanda age group and an initiated first-grade elder." It is not surprising then that Dr. Leakey is an unequivocal champion of native rights in the many and varied problems that beset the East African colony. Four agreeable "background" chapters precede the discussion of the problems—the native in his relations with administration, missionary, settler, science, Nairobi, and education—and there is a final chapter on the future of Kenya.

Dr. Leakey lays many of the ills of administration to the custom of frequent transfer of officials—a handicap best realized by the anthropologist, who is fully aware of the profound differences between tribes. The misunderstandings in Kenya, says Dr. Leakey, are due to the failure of the European to realize the native point of view, and it is over the land question that the greatest misunderstandings have arisen. Here relations with the settler are most acute, and here most protest will be aroused against "Kenya." (A statement of some aspects of the "Settlers' Case" appeared in the *Round Table* for December, 1935.) Furthermore, Dr. Leakey is not convinced that the Kenya highlands are a white man's country; not only is there the problem of climate in relation to health, but there are economic considerations—the remoteness from markets and the "insect pests, unreliable rainfall, and ever-increasing but slow desiccation." Tied up with the desiccation that Dr. Leakey believes is in progress is the soil-erosion problem, now recognized as of fundamental importance in East Africa as well as in the United States. Toward it Dr. Leakey seems to take a somewhat fatalistic attitude: although he admits that "it is probably true that excessive grazing by goats and sheep, and carelessness with fire in forest areas, is hastening the process," he expresses the opinion that climatic deterioration is the fundamental cause.

If Dr. Leakey's view of Kenya's problems is a partial one, his arguments, cogent in their clarity of statement, will nevertheless have to be taken into consideration in any plans for the future welfare of the colony.

A Soil Map of East Africa

G. Milne and others. **A Provisional Soil Map of East Africa (Kenya, Uganda, Tanganyika, and Zanzibar) with Explanatory Memoir.** 34 pp.; map, bibliogr. *Amani Memoirs.* East African Agricultural Research Station, Amani, Tanganyika Territory, 1936. 5s. 11 x 7½ inches.

The strange pattern of colors and the large white spaces of this soil map of East Africa on the scale of 1 : 2,000,000 proclaim its provisional character apart from the emphasis laid in the text on the scantiness of the available data. That it is possible to construct such a map at all is a tribute to its authors. Credit also is due to them for their careful discrimination of the quality of the data used. The devices used to represent soil complexes may be noted; for example, the *catena*, or recurring complex. "Throughout districts characterised by an undulating or hummocky topography, or rather by a given set of physiographic conditions of which this type of relief is one, certain sequences of changing soil profiles are found repeated." "Over a large part of the dissected peneplain of Uganda . . . the complex consists of the sequence of soils encountered between the crest of a low hill and the floor of the adjacent swamp, the profile changing from point to point of this traverse in accordance with conditions of drainage and past history of the land surface. . . . The distribution of soil types is a function of local differences of level and slope, which govern drainage; and in all of them we misrepresent matters if the map is made to show but a single dominant soil. . . . The means adopted for representing catenary complexes on the map is to depict the area in question in vertical stripes, using the colours and rulings that stand for the two, three or four principal member-soils. The most freely-drained soil is that shown in the stripe at the left-hand side, and

those shown next successively to the right occupy sites on successively lower ground. The approximate relative extent of the several soils of the catena is expressed qualitatively in the relative width of the respective stripes."

The classification of soil types perforce is provisional also. It distinguishes as major groups: desert, saline, and plains soils, black or gray clays, mottled clays, nonlaterized red earths, laterized red earths, plateau soils, podsolized soils, and lithological types. The more important groups are subdivided. There are brief notations on the soil types and a brief regional discussion. It is proposed to give in later publications detailed descriptions of typical soils from each group and to describe "the associated circumstances of vegetation, climate, geology, relief, and agricultural uses."

The islands of Zanzibar and Pemba are shown on an inset on a scale three times that of the main map.

Geological Map of Tanganyika

E. O. Teale. **Provisional Geological Map of Tanganyika, with Explanatory Notes on the Geological Formations and Mineral Occurrences and a Chronological Table (Provisional) of the Former.** 50 pp.; maps, bibliogr. *Tanganyika Territory Dept. of Lands and Mines, Geol. Division Bull. No. 6 (Revised Edit.).* Government Printer, Dar es Salaam, 1936. 4s. 10 x 7 inches.

The provisional geological map of Tanganyika Territory published in 1932 has been republished in revised form. Accompanying the map is a "Physiographical Map of Tanganyika Territory" (see *Geogr. Rev.*, Vol. 23, 1933, pp. 402–413) on the same scale, 1 : 3,000,000, and a table of the geological formations. The text briefly describes the physical features, geological succession, tectonic history, and economic geology of the Territory.

Wind and Precipitation over Southwestern Asia

G. Bauer. **Luftzirkulation und Niederschlagsverhältnisse in Vorderasien.** Maps, diagrs., bibliogr. *Gerlands Beiträge zur Geophysik*, Vol. 45, 1935, pp. 381–548.

"Vorderasien" in this work means the Asiatic land area south of the latitude of the Black and Caspian Seas and west of the longitude of the Indian-Afghan frontier. Its larger parts are thus Asia Minor, the Iranian Plateau, Mesopotamia, and the Arabian Peninsula. The nucleus of the work is a fine series of maps, as follows: atmospheric pressure in winter and summer (December-January-February and June-July-August respectively) and in the individual months of the transition seasons; surface winds in the same divisions of the year, represented by streamlines; and mean precipitation reduced to the 30-year period 1895–1924, mapped for individual months, the customary four seasons, and the entire year. The maps of pressure were drawn from existing maps and compilations, those of circulation and precipitation worked up anew from highly scattered sources. The text includes an elaborate discussion of the maps, arranged to demonstrate the development from season to season of the annual cycle, and a superstructure of descriptive matter. The descriptive detail is local and episodic rather than synoptic, as is inevitable when the primary material is of the sort used, and refers to a region that is still a no man's land of synoptic meteorology. In an age of three-dimensional contemplation of the atmosphere and of daily synoptic charts covering areas up to the magnitude of a hemisphere Bauer's account is somewhat anachronistically reminiscent of the regional climatologic writings of Julius Hann. That it is nonetheless illuminating is witness to the lasting vitality and usefulness of Hann's methods.

Without some information not contained on maps of means the distribution of precipitation in the Near East would be incomprehensible. Precipitation falls

almost exclusively in winter; but the map of air movement in winter shows an equally exclusive dominance of air from the interior of Asia, which only under exceptional circumstances could yield precipitation. In the resolution of this conflicting evidence on the maps of means the author exercises most of the reconstructive ingenuity called for by his materials. It is applied to piecing together evidence that winter precipitation is occasioned by cyclones that find their way into or across his area (at 40° N. about as wide as the United States in the same latitude) from the eastern Mediterranean but that leave no mark on maps of mean pressure or resultant air movement.

Bauer's data provide a certain amount of material for the discussion of one general problem, among others, that deserves to be taken up systematically: the effect of differences in temperature between neighboring land and sea surfaces on the yield of rain from maritime air over land—a discussion that would go beyond the familiar correlation between cold sea surfaces and drought over adjacent lands. Bauer records in numbers the steady decrease in relative humidity observed in air from the Mediterranean as it moves up the Nile Valley in summer and refers the rainless summers of the Near East in general to a similar lowering of relative humidity in the air—practically all of maritime origin—that flows over it throughout the warm season. In higher latitudes, on the other hand, air of the same origin brings summer rain. The question posed by this contrast in behavior of maritime air is one of wide significance; not only the Asiatic, but also the North American, Southwest might contribute useful observations toward its solution.

JOHN LEIGHLY

ECONOMIC GEOGRAPHY OF ASIATIC RUSSIA

ERICH THIEL. **Verkehrsgeographie von Russisch-Asien.** xi and 324 pp.; maps, ills., bibliogr. (Osteuropäische Forschungen, im Auftrage der Deutschen Gesellschaft zum Studium Osteuropas, N. S. Vol. 17.) Ost-Europa-Verlag, Königsberg and Berlin, 1934. 9 x 6 inches.

This volume is a welcome addition to the literature on the geography of Asiatic Russia. It was prepared under the guidance of Dr. Arved Schultz of the University of Königsberg, who possesses much firsthand knowledge of northern Asia.

The first part of the book gives a general review of the natural landscape and transportation problems; the second part treats in detail the subject of transportation and communications. A scattering of somewhat sketchy maps and many tables support the presentation. Many of the statistical data unfortunately are not up to date; in fact, for some items the latest data are those of 1911 or 1917 or thereabouts. This is not entirely the fault of the author, however, but is due in many instances to his dependence on Russian sources, which, as is well known, have not always maintained continuous records. An excellent bibliography and interesting photographs conclude the work.

Although the first part of the book affords interesting reading, the second part is essentially encyclopedic but, even so, is not at all dull. The author emphasizes the fact that Asiatic Russia for the most part is a continuation of the eastern European plain and that central and eastern Asia are virtually blocked off from this plain and thus denies the often-made statement that the U. S. S. R. faces east rather than west and that its future lies in the Orient. Transportation by river is difficult not alone because of low temperatures but because of the slightness of the stream gradients and the seasonal floods. On the other hand, the slightness of the gradient makes navigation upstream just about as easy as downstream. In overland transportation problems, the paucity of railroads makes climate play a critical role. Therefore the author devotes considerable attention to the climatic characteristics of the region and correlates with transportation such elements as river ice, snow covering, swamp-

lands, vegetation covering, and high winds. In spite of low winter temperatures, winter at present is the most convenient time of year for travel; for then the poorly drained lands offer substantial roadbeds, and the summer plague of mosquitoes is in abeyance.

EUGENE VAN CLEEF

PHYSICS OF THE EARTH

HAROLD JEFFREYS. **Earthquakes and Mountains.** x and 183 pp.; maps, diagrs., ills., index. Methuen & Co., London, 1935. 7s. 6d. 7½ x 5 inches.

This little book provides "an account of the modern study of the Physics of the Earth in general language, for the benefit of those interested in natural phenomena and their causes." The title is aptly chosen, since mountains are a superficial effect of internal forces and conditions to which earthquakes also bear testimony. Characteristically the author places the reader's feet on firm ground by discussing in the introductory chapter some fundamental principles of mechanics. A chapter on earthquakes summarizes the present status of seismology and gives Jeffreys' reasons for considering the core of the earth liquid. Succeeding chapters discuss the shape of the earth, the ability of the earth to support surface irregularities, radioactivity in relation to the earth's history, and the tides set up in the body of the earth by attraction of the moon and sun.

Finally, in a discussion of the mechanics of mountain making, the author proposes a theory that strongly resembles the conception of Haarmann (Die Oszillationstheorie, Stuttgart, 1930). Jeffreys sees geophysical evidence that a granitic layer in the earth's crust overlies a layer of intermediate composition, which in turn rests on a layer of higher density. If the granitic and intermediate layers are thickened locally by horizontal compression, a protuberance is formed downward as well as upward, to maintain isostatic equilibrium. Sedimentary strata arched above the thickened segment may slide down its flanks, and thus strong folding and thrust faulting may result directly from the action of gravity. According to this theory, the nappes of the Alps and similar structural features in other mountain belts have resulted from gigantic landslides, for which potential was furnished by localized swellings that suggest the "geotumors" of Haarmann. Daly also has proposed sliding as an immediate cause of folding and thrusting (Our Mobile Earth, New York and London, 1926). Geologists have given the proposal a sympathetic hearing but will reserve judgment until critical geological evidence to test the theory has been found.

CHESTER R. LONGWELL

PRECURSOR OF COLUMBUS?

ALBERTO MAGNAGHI. **Precursori di Colombo? Il tentativo di viaggio transoceanico dei genovesi fratelli Vivaldi nel 1291.** 155 pp.; maps. *Memorie Reale Soc. Geogr. Italiana*, Vol. 18. Società Anonima Italiana Arti Grafiche, Rome, 1935. L. 20. 9½ x 7 inches.

In the month of May, 1291, two brothers, Ugolino and Vadino Vivaldi, sailed west from the port of Genoa and out through the Strait of Gibraltar in the hope of attaining "per mare Oceanum . . . ad partes Indiæ." Although two Franciscan friars accompanied the expedition, the primary purpose was to bring back "mercimonia utilia" rather than to make converts to Christianity. The attempt was recognized as bold, even at the time. It inspired one of the great passages of the Inferno, the voyage of Ulysses beyond the Pillars of Hercules into the mysterious ocean where he perished, a victim of man's fateful desire to penetrate the unknown. Like the missionaries Pian de Carpine and Rubruck, humble adventurers of the faith in Asia, like Marco Polo, hero of merchant adventure, the two Genoese brothers were also pioneers. But pioneers of what?

Modern historians have generally assumed that the Vivaldi expedition had as its objective the circumnavigation of Africa, a feat that had not been attempted since the days of Hanno and Eudoxus in antiquity. On the basis of extremely slender evidence, scholars have woven fanciful stories. Professor Magnaghi's book attempts to strip away accumulated legend, to isolate the fundamental sources and establish the whole question on a critical footing. In the process he pays his respects to a number of modern scholars, principally La Roncière, *grand seigneur* among historians of geography. On the whole, it must be admitted that Magnaghi is well on top of his argument and shows once more what solid work Italian scholars are doing in this field.

The most important part of the discussion centers in the examination of the actual sources on which our knowledge of the Vivaldi expedition is based. Only one is of fundamental value, a short passage in the annals of Jacopo Doria, written in 1294, three years after the expedition had sailed, at a moment when concern for its fate would naturally be acute. According to the annalist the ships were last seen at Gozora, on the West African coast about opposite the Canary Islands. Since then no word had been received. In the sixteenth century the expedition was again mentioned by two Genoese historians, Agostino Giustiniani and Uberto Folieta, who independently confirm the account of Jacopo Doria without altering it appreciably.

The questionable part of the story goes back to two intermediate sources: the fourteenth-century "Libro del conosçimiento" by an anonymous Spanish Franciscan and the so-called "Itinerarium" of Usodimare, dated 1455. It is from these rather dubious documents that most of the romantic legend has been drawn—shipwreck on the African coast, captivity in Abyssinia, and even a problematical rescue expedition undertaken by Sorleone Vivaldo, son of Ugolino. Very little is left of these sources and their modern embroiderers after Professor Magnaghi has finished his criticism.

What, then, is the story of the expedition? That the impetus behind it was commercial and that the result was failure—probably shipwreck off the African coast—Magnaghi is prepared to accept. As for its goal, five possibilities are suggested: (1) Abyssinia, to be reached by sailing up an imaginary river or gulf cutting through Africa from the Atlantic coast, such as was shown on many maps of the period; (2) Abyssinia, to be reached by circumnavigating Africa; (3) the Persian Gulf, where Genoese merchants were already established; (4) India, to be reached directly by the Indian Ocean; (5) *India Ultima* or Cathay, to be reached by sailing *west*. It will be observed that the first four of these possibilities anticipate the voyages of the Portuguese, the fifth those of Columbus.

Professor Magnaghi advances several good arguments against the first four and decides cautiously in favor of the fifth. The principal Genoese sources, which alone seem to have value, are agreed in specifying India or "partes Indiæ" as the goal that it was hoped could be reached by sailing toward the west. Nothing explicit is said of the circumnavigation of Africa. Moreover, an examination of the geographical and cartographical knowledge of the time as exemplified in the Vesconte world map suggests that a direct westward traverse would appear just as feasible as the long, hazardous trip around Africa. In fact, the general appearance of the problem at the end of the thirteenth century was about the same as at the end of the fifteenth. The geographical conceptions of Columbus, derived largely from Pierre d'Ailly's "Imago mundi," were not vastly much more sophisticated than those of the high Middle Ages.

Professor Magnaghi is fully aware that he is setting forth a mere hypothesis. The "precursor of Columbus" has been a will-o'-the-wisp for historians. We may agree, however, that whether the Vivaldi were forerunners of Columbus or of Vasco da Gama in their project, at least of its kind it was an enterprise both "in reality and in imagination above that which had been previously ventured by human courage."

DANA B. DURAND

The Hakluyt Writings

E. G. R. Taylor, edit. **The Original Writings & Correspondence of the Two Richard Hakluyts.** Vol. 1, xiv and 210 pp.; Vol. 2, pp. x and 211–516; maps, ills., bibliogr., index. *Hakluyt Soc. Publs.*, Ser. 2, Vols. 76 and 77. London, 1935. 9 x 6 inches.

The historian of Tudor geography has here brought together for the first time the scattered treatises and letters (and other personalia) of two Elizabethan geographers. She has combed the published works of the younger Hakluyt and has derived from the state papers and elsewhere the letters and documents that both Hakluyts wrote and that were written to them. Most of the material has been published before, but Professor Taylor has usually made fresh transcripts of the originals and has produced an authoritative collection.

The 66-page introduction is at the same time a running commentary on the documents and a skillfully compact life of the Hakluyt cousins. Professor Taylor has again added to our knowledge of them. She has, for example, completed the Hakluyt genealogy. From her knowledge of the voyage projects of the time, she has, moreover, deepened the meaning of some of the advisory activities of the cousins, and she has extended the circle of their acquaintance with intellectuals and with men of action. Altogether she has reëmphasized the value of the geographer to the men who planned the expansion of England.

The miscellaneous nature of the Hakluyt writings will perhaps be a disappointment to the student of geography. The elder Hakluyt wrote and collected entirely "practical" information; the younger was an editor and translator. The most striking contributions of the elder are the studies of Mexico and Newfoundland that he obtained from travelers and the advices that he wrote for colonies in Newfoundland and Virginia, for the discovery of China by way of the Northeast Passage, and for the new trade with Turkey. This is a considerable variety, after all. His "specialty" was economic geography, and he had a particular interest, Professor Taylor points out, in botany and a particular knowledge of English foreign trade.

The younger Hakluyt's professional writings may be divided into two classes. One consists of his letters and his prefaces, which may be called his commentary on travel, especially on colonizing; the other includes his treatises and advices on oversea matters. Of the first group, I think the most interesting is the dedication of his edition of Peter Martyr's "Decades of the New World," the first history of the Spanish discoveries. This dedication is now first reprinted and translated from the Latin. Hakluyt's praise here of his predecessor, as both historian and geographer, is an indication of his own professional ideals.

Of Hakluyt's advices, first interest attaches to his plan for fortifying the Strait of Magellan, which Professor Taylor discovered and identified. This is his first political document. His two advices to the new East India Company are usefully brought together here, since they testify to Hakluyt's scope. One is the list of Portuguese settlements in the East—a political discussion. The other is a list of the spice markets—a kind of merchant's handbook.

The most striking document is the so-called "Discourse of Western Planting," which has been relatively inaccessible. This lengthy statement of colonial policy, written before Raleigh sent out his first Virginia colony, strikes one afresh as a sound and thorough discussion. Read along with the similar advices of both the Hakluyts, it increases our respect for both the geographical knowledge and the political alertness of the two geographers.

I must regret one omission, however justifiable. Hakluyt's advices to the Dutch explorers of the Northeast Passage are apparently no longer extant, having perhaps been lost by Barents in his "farthest north" winter on Novaya Zemlya. Their tenor can be judged, however, by the remarks about them by the man who conveyed them to Holland. I wish that the letters containing these remarks had been included.

Insufficient though they are, they add another to the all too few glimpses of the geographer at work. Another less important omission is that of Hakluyt's own notes on Acosta's "West Indies," which might have been added for the sake of completeness.

I may add that since Professor Taylor has given so much, we continue to ask for more. Most of the geographical works of John Dee, the senior Elizabethan scientist, remain unprinted. We hope that they may be rescued and interpreted by her competent hand.

GEORGE B. PARKS

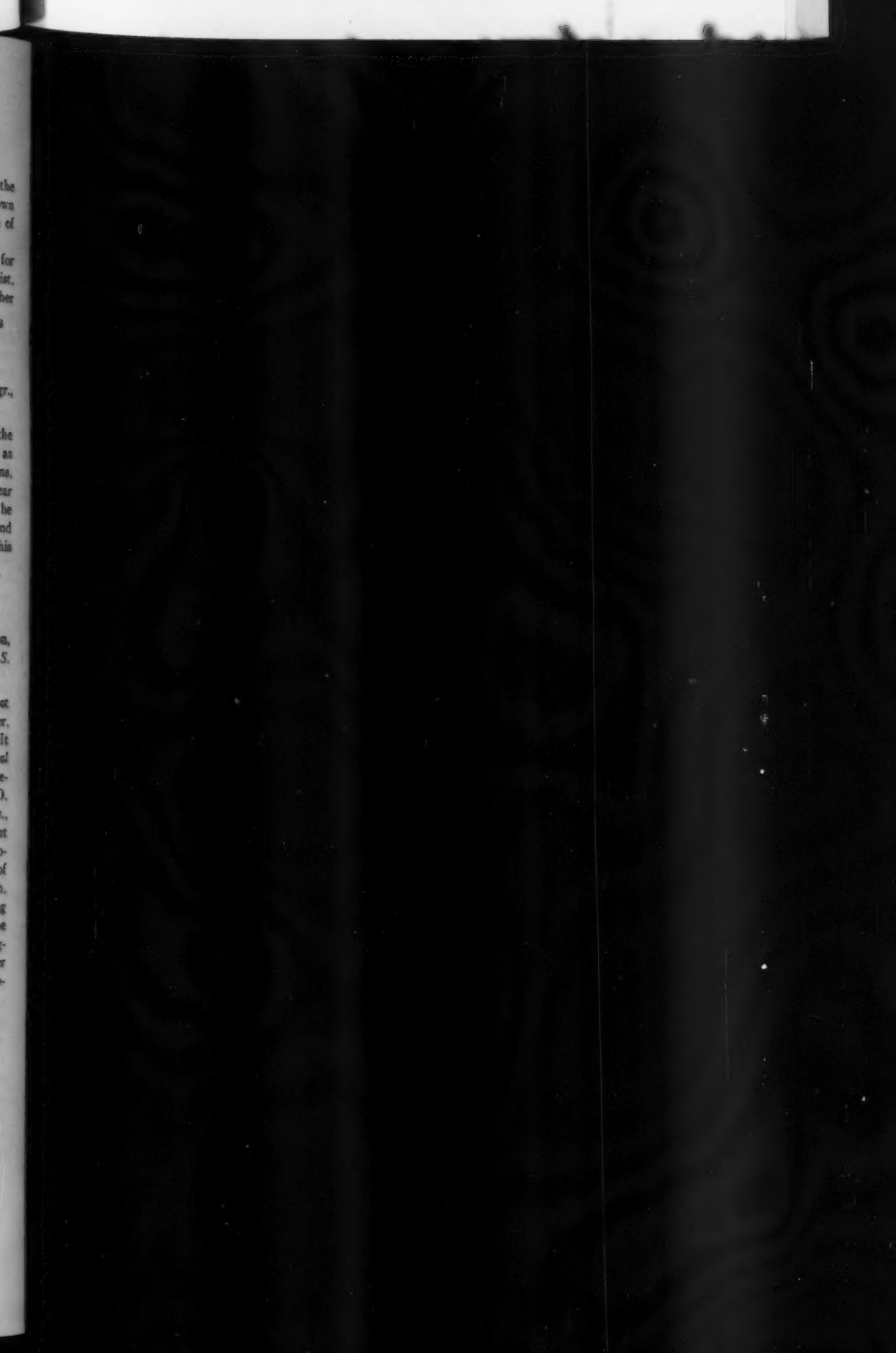
ALPINE PASSES IN ROMAN DAYS

WALTER WOODBURN HYDE. **Roman Alpine Routes.** xvi and 248 pp.; map, bibliogr., index. *Memoirs Amer. Philos. Soc.*, Vol. 2, 1935.

Professor Hyde here gives an account of the Alpine passes known and used by the Romans. He seeks to identify the passes used on the several historical occasions, as far as that may be done with the help of known documents and previous discussions, and in general supplies the necessary historical background. It does not appear that he has appreciably contributed to the solution of disputed questions; but he has provided a readable book, made serviceable by the addition of a good map and rendered especially pleasant by the evident pleasure the author has taken in his numerous excursions in the Alps.

W. A. HEIDEL

THE MONUMENT VALLEY-NAVAJO MOUNTAIN COUNTRY

ARTHUR A. BAKER. **Geology of the Monument Valley-Navajo Mountain Region, San Juan County, Utah.** vi and 106 pp.; maps, diagrs., ills., index. *U. S. Geol. Survey Bull. 865*, 1936. 60 cents. 9 x 6 inches.

This bulletin treats of the geography and geology of a portion of southernmost Utah south of the canyon of the San Juan River and west of the Colorado River, in the canyon lands of the Colorado, an area previously not mapped in detail. It is part of the "Navajo country" described in the *Bulletin of the American Geographical Society* (Vol. 47, 1915, pp. 561–577 and 652–672) and includes, among other remarkable topographic features, the celebrated Rainbow Natural Bridge (see H. D. Miser, K. W. Trimble, and Sidney Paige: The Rainbow Bridge, Utah, *Geogr. Rev.*, Vol. 13, 1923, pp. 518–531). The region, virtually uninhabited and even yet but little traveled, exhibits to a notable degree the remarkable landforms of the geomorphic province of which it is a part. In addition to a geologic map on a scale of 1 : 96,000, the report includes a topographic map on a scale of 1 : 125,000, which, although compiled in the office from altitudes obtained primarily for illustrating the geology, is by far the best available topographic map of this area or any of the surrounding region. The report also includes a block diagram showing the topography of the region and its relation to the kind and distribution of bedrock, together with half-tone reproductions of photographs of some of the more striking topographic features.